

(1) A review of emissions reductions and progress made in implementing control measures to reduce emissions of direct PM_{2.5} and PM_{2.5} attainment plan precursors contributing to PM_{2.5} concentrations in the area;

(2) An analysis of changes in ambient air quality data for the area;

(3) Revised air quality modeling analysis to demonstrate attainment;

(4) Any new or revised control measures adopted by the State, as necessary to ensure attainment by the attainment date in the approved SIP of the nonattainment area.

§51.1012 Requirement for contingency measures.

Consistent with section 172(c)(9) of the Act, the State must submit in each attainment plan specific contingency measures to be undertaken if the area fails to make reasonable further progress, or fails to attain the PM_{2.5} NAAQS by its attainment date. The contingency measures must take effect without significant further action by the State or EPA.

APPENDIXES A–K TO PART 51 [RESERVED]

APPENDIX L TO PART 51—EXAMPLE REGULATIONS FOR PREVENTION OF AIR POLLUTION EMERGENCY EPISODES

The example regulations presented herein reflect generally recognized ways of preventing air pollution from reaching levels that would cause imminent and substantial endangerment to the health of persons. States are required under subpart H to have emergency episodes plans but they are not required to adopt the regulations presented herein.

1.0 *Air pollution emergency.* This regulation is designed to prevent the excessive buildup of air pollutants during air pollution episodes, thereby preventing the occurrence of an emergency due to the effects of these pollutants on the health of persons.

1.1 *Episode criteria.* Conditions justifying the proclamation of an air pollution alert, air pollution warning, or air pollution emergency shall be deemed to exist whenever the Director determines that the accumulation of air pollutants in any place is attaining or has attained levels which could, if such levels are sustained or exceeded, lead to a substantial threat to the health of persons. In making this determination, the Director will be guided by the following criteria:

(a) *Air Pollution Forecast:* An internal watch by the Department of Air Pollution Control shall be actuated by a National Weather Service advisory that Atmospheric Stagnation Advisory is in effect or the equivalent local forecast of stagnant atmospheric condition.

(b) *Alert:* The Alert level is that concentration of pollutants at which first stage control actions is to begin. An Alert will be declared when any one of the following levels is reached at any monitoring site:

SO₂—800 µg/m³ (0.3 p.p.m.), 24-hour average.
PM₁₀—350 µg/m³, 24-hour average.
CO—17 mg/m³ (15 p.p.m.), 8-hour average.
Ozone (O₃)—400 µg/m³ (0.2 ppm)-hour average.
NO₂—1130 µg/m³ (0.6 p.p.m.), 1-hour average,
282 µg/m³ (0.15 p.p.m.), 24-hour average.

In addition to the levels listed for the above pollutants, meteorological conditions are such that pollutant concentrations can be expected to remain at the above levels for twelve (12) or more hours or increase, or in the case of ozone, the situation is likely to reoccur within the next 24-hours unless control actions are taken.

(c) *Warning:* The warning level indicates that air quality is continuing to degrade and that additional control actions are necessary. A warning will be declared when any one of the following levels is reached at any monitoring site:

SO₂—1,600 µg/m³ (0.6 p.p.m.), 24-hour average.
PM₁₀—420 µg/m³, 24-hour average.
CO—34 mg/m³ (30 p.p.m.), 8-hour average.
Ozone (O₃)—800 µg/m³ (0.4 p.p.m.), 1-hour average.
NO₂—2,260 µg/m³ (1.2 ppm)—1-hour average;
565 µg/m³ (0.3 ppm), 24-hour average.

In addition to the levels listed for the above pollutants, meteorological conditions are such that pollutant concentrations can be expected to remain at the above levels for twelve (12) or more hours or increase, or in the case of ozone, the situation is likely to reoccur within the next 24-hours unless control actions are taken.

(d) *Emergency:* The emergency level indicates that air quality is continuing to degrade toward a level of significant harm to the health of persons and that the most stringent control actions are necessary. An emergency will be declared when any one of the following levels is reached at any monitoring site:

SO₂—2,100 µg/m³ (0.8 p.p.m.), 24-hour average.
PM₁₀—500 µg/m³, 24-hour average.
CO—46 mg/m³ (40 p.p.m.), 8-hour average.
Ozone (O₃)—1,000 µg/m³ (0.5 p.p.m.), 1-hour average.
NO₂—3,000 µg/m³ (1.6 ppm), 1-hour average; 750 µg/m³ (0.4 ppm), 24-hour average.

In addition to the levels listed for the above pollutants, meteorological conditions are such that pollutant concentrations can

be expected to remain at the above levels for twelve (12) or more hours or increase, or in the case of ozone, the situation is likely to reoccur within the next 24-hours unless control actions are taken.

(e) *Termination*: Once declared, any status reached by application of these criteria will remain in effect until the criteria for that level are no longer met. At such time, the next lower status will be assumed.

1.2 *Emission reduction plans*. (a) Air Pollution Alert—When the Director declares an Air Pollution Alert, any person responsible for the operation of a source of air pollutants as set forth in Table I shall take all Air Pollution Alert actions as required for such source of air pollutants and shall put into effect the preplanned abatement strategy for an Air Pollution Alert.

(b) Air Pollution Warning—When the Director declares an Air Pollution Warning, any person responsible for the operation of a source of air pollutants as set forth in Table II shall take all Air Pollution Warning actions as required for such source of air pollutants and shall put into effect the preplanned abatement strategy for an Air Pollution Warning.

(c) Air Pollution Emergency—When the Director declares an Air Pollution Emergency, any person responsible for the operation of a source of air pollutants as described in Table III shall take all Air Pollution Emergency actions as required for such source of air pollutants and shall put into effect the preplanned abatement strategy for an Air Pollution Emergency.

(d) When the Director determines that a specified criteria level has been reached at one or more monitoring sites solely because of emissions from a limited number of sources, he shall notify such source(s) that the preplanned abatement strategies of Tables I, II, and III or the standby plans are required, insofar as it applies to such source(s), and shall be put into effect until the criteria of the specified level are no longer met.

1.3 *Preplanned abatement strategies*. (a) Any person responsible for the operation of a source of air pollutants as set forth in Tables I-III shall prepare standby plans for reducing the emission of air pollutants during periods of an Air Pollution Alert, Air Pollution Warning, and Air Pollution Emergency. Standby plans shall be designed to reduce or eliminate emissions of air pollutants in accordance with the objectives set forth in Tables I-III which are made a part of this section.

(b) Any person responsible for the operation of a source of air pollutants not set

forth under section 1.3(a) shall, when requested by the Director in writing, prepare standby plans for reducing the emission of air pollutants during periods of an Air Pollution Alert, Air Pollution Warning, and Air Pollution Emergency. Standby plans shall be designed to reduce or eliminate emissions of air pollutants in accordance with the objectives set forth in Tables I-III.

(c) Standby plans as required under section 1.3(a) and (b) shall be in writing and identify the sources of air pollutants, the approximate amount of reduction of pollutants and a brief description of the manner in which the reduction will be achieved during an Air Pollution Alert, Air Pollution Warning, and Air Pollution Emergency.

(d) During a condition of Air Pollution Alert, Air Pollution Warning, and Air Pollution Emergency, standby plans as required by this section shall be made available on the premises to any person authorized to enforce the provisions of applicable rules and regulations.

(e) Standby plans as required by this section shall be submitted to the Director upon request within thirty (30) days of the receipt of such request; such standby plans shall be subject to review and approval by the Director. If, in the opinion of the Director, a standby plan does not effectively carry out the objectives as set forth in Table I-III, the Director may disapprove it, state his reason for disapproval and order the preparation of an amended standby plan within the time period specified in the order.

TABLE I—ABATEMENT STRATEGIES EMISSION
REDUCTION PLANS ALERT LEVEL

Part A. General

1. There shall be no open burning by any persons of tree waste, vegetation, refuse, or debris in any form.
2. The use of incinerators for the disposal of any form of solid waste shall be limited to the hours between 12 noon and 4 p.m.
3. Persons operating fuel-burning equipment which required boiler lancing or soot blowing shall perform such operations only between the hours of 12 noon and 4 p.m.
4. Persons operating motor vehicles should eliminate all unnecessary operations.

Part B. Source curtailment

Any person responsible for the operation of a source of air pollutants listed below shall take all required control actions for this Alert Level.

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| Source of air pollution | Control action |
|--|---|
| 1. Coal or oil-fired electric power generating facilities | a. Substantial reduction by utilization of fuels having low ash and sulfur content. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Substantial reduction by diverting electric power generation to facilities outside of Alert Area. |
| 2. Coal and oil-fired process steam generating facilities | a. Substantial reduction by utilization of fuels having low ash and sulfur content. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Substantial reduction of steam load demands consistent with continuing plant operations. |
| 3. Manufacturing industries of the following classifications: Primary Metals Industry. Petroleum Refining Operations. Chemical Industries. Mineral Processing Industries. Paper and Allied Products. Grain Industry. | a. Substantial reduction of air pollutants from manufacturing operations by curtailing, postponing, or deferring production and all operations. b. Maximum reduction by deferring trade waste disposal operations which emit solid particles, gas vapors or malodorous substances. c. Maximum reduction of heat load demands for processing. d. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. |

TABLE II—EMISSION REDUCTION PLANS

WARNING LEVEL

Part A. General

1. There shall be no open burning by any persons of tree waste, vegetation, refuse, or debris in any form.
2. The use of incinerators for the disposal of any form of solid waste or liquid waste shall be prohibited.
3. Persons operating fuel-burning equipment which requires boiler lancing or soot

blowing shall perform such operations only between the hours of 12 noon and 4 p.m.

4. Persons operating motor vehicles must reduce operations by the use of car pools and increased use of public transportation and elimination of unnecessary operation.

Part B. Source curtailment

Any person responsible for the operation of a source of air pollutants listed below shall take all required control actions for this Warning Level.

| Source of air pollution | Control action |
|---|---|
| 1. Coal or oil-fired process steam generating facilities | a. Maximum reduction by utilization of fuels having lowest ash and sulfur content. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Maximum reduction by diverting electric power generation to facilities outside of Warning Area. |
| 2. Oil and oil-fired process steam generating facilities | a. Maximum reduction by utilization of fuels having the lowest available ash and sulfur content. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Making ready for use a plan of action to be taken if an emergency develops. |
| 3. Manufacturing industries which require considerable lead time for shut-down including the following classifications: Petroleum Refining. Chemical Industries. Primary Metals Industries. Glass Industries. Paper and Allied Products. | a. Maximum reduction of air contaminants from manufacturing operations by, if necessary, assuming reasonable economic hardships by postponing production and allied operation. b. Maximum reduction by deferring trade waste disposal operations which emit solid particles, gases, vapors or malodorous substances. c. Maximum reduction of heat load demands for processing. d. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing or soot blowing. |
| 4. Manufacturing industries require relatively short lead times for shut-down including the following classifications: Primary Metals Industries. Chemical Industries. Mineral Processing Industries. Grain Industry. | a. Elimination of air pollutants from manufacturing operations by ceasing, curtailing, postponing or deferring production and allied operations to the extent possible without causing injury to persons or damage to equipment. b. Elimination of air pollutants from trade waste disposal processes which emit solid particles, gases, vapors or malodorous substances. c. Maximum reduction of heat load demands for processing. d. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing or soot blowing. |

TABLE III—EMISSION REDUCTION PLANS

EMERGENCY LEVEL

Part A. General

1. There shall be no open burning by any persons of tree waste, vegetation, refuse, or debris in any form.
2. The use of incinerators for the disposal of any form of solid or liquid waste shall be prohibited.
3. All places of employment described below shall immediately cease operations.
 - a. Mining and quarrying of nonmetallic minerals.
 - b. All construction work except that which must proceed to avoid emergent physical harm.
 - c. All manufacturing establishments except those required to have in force an air pollution emergency plan.
 - d. All wholesale trade establishments; i.e., places of business primarily engaged in selling merchandise to retailers, or industrial, commercial, institutional or professional users, or to other wholesalers, or acting as agents in buying merchandise for or selling merchandise to such persons or companies, except those engaged in the distribution of drugs, surgical supplies and food.
 - e. All offices of local, county and State government including authorities, joint meetings, and other public bodies excepting such agencies which are determined by the chief administrative officer of local, county, or State government, authorities, joint meetings and other public bodies to be vital for public safety and welfare and the enforcement of the provisions of this order.
 - f. All retail trade establishments except pharmacies, surgical supply distributors, and stores primarily engaged in the sale of food.

g. Banks, credit agencies other than banks, securities and commodities brokers, dealers, exchanges and services; offices of insurance carriers, agents and brokers, real estate offices.

h. Wholesale and retail laundries, laundry services and cleaning and dyeing establishments; photographic studios; beauty shops, barber shops, shoe repair shops.

i. Advertising offices; consumer credit reporting, adjustment and collection agencies; duplicating, addressing, blueprinting; photocopying, mailing, mailing list and stenographic services; equipment rental services, commercial testing laboratories.

j. Automobile repair, automobile services, garages.

k. Establishments rendering amusement and recreational services including motion picture theaters.

l. Elementary and secondary schools, colleges, universities, professional schools, junior colleges, vocational schools, and public and private libraries.

4. All commercial and manufacturing establishments not included in this order will institute such actions as will result in maximum reduction of air pollutants from their operation by ceasing, curtailing, or postponing operations which emit air pollutants to the extent possible without causing injury to persons or damage to equipment.

5. The use of motor vehicles is prohibited except in emergencies with the approval of local or State police.

Part B. Source curtailment

Any person responsible for the operation of a source of air pollutants listed below shall take all required control actions for this Emergency Level.

| Source of air pollution | Control action |
|---|---|
| 1. Coal or oil-fired electric power generating facilities | a. Maximum reduction by utilization of fuels having lowest ash and sulfur content. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing or soot blowing. c. Maximum reduction by diverting electric power generation to facilities outside of Emergency Area. |
| 2. Coal and oil-fired process steam generating facilities | a. Maximum reduction by reducing heat and steam demands to absolute necessities consistent with preventing equipment damage. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Taking the action called for in the emergency plan. |
| 3. Manufacturing industries of the following classifications: Primary Metals Industries. Petroleum Refining. Chemical Industries. Mineral Processing Industries. Grain Industry. Paper and Allied Products. | a. Elimination of air pollutants from manufacturing operations by ceasing, curtailing, postponing or deferring production and allied operations to the extent possible without causing injury to persons or damage to equipment. b. Elimination of air pollutants from trade waste disposal processes which emit solid particles, gases, vapors or malodorous substances. c. Maximum reduction of heat load demands for processing. d. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing or soot blowing. |

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(Secs. 110, 301(a), 313, 319, Clean Air Act (42 U.S.C. 7410, 7601(a), 7613, 7619))

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APPENDIX M TO PART 51—RECOMMENDED TEST METHODS FOR STATE IMPLE- MENTATION PLANS

Method 201—Determination of PM₁₀ Emissions (Exhaust Gas Recycle Procedure).

Method 201A—Determination of PM₁₀ Emissions (Constant Sampling Rate Procedure).

Method 202—Determination of Condensible Particulate Emissions From Stationary Sources

Method 203A—Visual Determination of Opacity of Emissions from Stationary Sources for Time-Averaged Regulations.

Method 203B—Visual Determination of Opacity of Emissions from Stationary Sources for Time-Exception Regulations.

Method 203C—Visual Determination of Opacity of Emissions from Stationary Sources for Instantaneous Regulations.

Method 204—Criteria for and Verification of a Permanent or Temporary Total Enclosure.

Method 204A—Volatile Organic Compounds Content in Liquid Input Stream.

Method 204B—Volatile Organic Compounds Emissions in Captured Stream.

Method 204C—Volatile Organic Compounds Emissions in Captured Stream (Dilution Technique).

Method 204D—Volatile Organic Compounds Emissions in Uncaptured Stream from Temporary Total Enclosure.

Method 204E—Volatile Organic Compounds Emissions in Uncaptured Stream from Building Enclosure.

Method 204F—Volatile Organic Compounds Content in Liquid Input Stream (Distillation Approach).

Method 205—Verification of Gas Dilution Systems for Field Instrument Calibrations

Presented herein are recommended test methods for measuring air pollutant emanating from an emission source. They are provided for States to use in their plans to meet the requirements of subpart K—Source Surveillance.

The State may also choose to adopt other methods to meet the requirements of subpart K of this part, subject to the normal plan review process.

The State may also meet the requirements of subpart K of this part by adopting, again subject to the normal plan review process, any of the relevant methods in appendix A to 40 CFR part 60.

METHOD 201—DETERMINATION OF PM₁₀ EMISSIONS

(EXHAUST GAS RECYCLE PROCEDURE)

1. Applicability and Principle

1.1 Applicability. This method applies to the in-stack measurement of particulate matter (PM) emissions equal to or less than an aerodynamic diameter of nominally 10 μ m (PM₁₀) from stationary sources. The EPA recognizes that condensible emissions not collected by an in-stack method are also PM₁₀, and that emissions that contribute to ambient PM₁₀ levels are the sum of condensible emissions and emissions measured by an in-stack PM₁₀ method, such as this method or Method 201A. Therefore, for establishing source contributions to ambient levels of PM₁₀, such as for emission inventory purposes, EPA suggests that source PM₁₀ measurement include both in-stack PM₁₀ and condensible emissions. Condensible emissions may be measured by an impinger analysis in combination with this method.

1.2 Principle. A gas sample is isokinetically extracted from the source. An in-stack cyclone is used to separate PM greater than PM₁₀, and an in-stack glass fiber filter is used to collect the PM₁₀. To maintain isokinetic flow rate conditions at the tip of the probe and a constant flow rate through the cyclone, a clean, dried portion of the sample gas at stack temperature is recycled into the nozzle. The particulate mass is determined gravimetrically after removal of uncombined water.

2. Apparatus

NOTE: Method 5 as cited in this method refers to the method in 40 CFR part 60, appendix A.

2.1 Sampling Train. A schematic of the exhaust of the exhaust gas recycle (EGR) train is shown in Figure 1 of this method.

2.1.1 Nozzle with Recycle Attachment. Stainless steel (316 or equivalent) with a sharp tapered leading edge, and recycle attachment welded directly on the side of the nozzle (see schematic in Figure 2 of this method). The angle of the taper shall be on the outside. Use only straight sampling nozzles. "Gooseneck" or other nozzle extensions designed to turn the sample gas flow 90°, as in Method 5 are not acceptable. Locate a thermocouple in the recycle attachment to measure the temperature of the recycle gas as shown in Figure 3 of this method. The recycle attachment shall be made of stainless steel and shall be connected to the probe and

nozzle with stainless steel fittings. Two nozzle sizes, e.g., 0.125 and 0.160 in., should be available to allow isokinetic sampling to be conducted over a range of flow rates. Calibrate each nozzle as described in Method 5, Section 5.1.

2.1.2 PM₁₀ Sizer. Cyclone, meeting the specifications in Section 5.7 of this method.

2.1.3 Filter Holder. 63mm, stainless steel. An Andersen filter, part number SE274, has been found to be acceptable for the in-stack filter.

NOTE: Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

2.1.4 Pitot Tube. Same as in Method 5, Section 2.1.3. Attach the pitot to the pitot lines with stainless steel fittings and to the cyclone in a configuration similar to that shown in Figure 3 of this method. The pitot lines shall be made of heat resistant material and attached to the probe with stainless steel fittings.

2.1.5 EGR Probe. Stainless steel, 15.9-mm (5/8-in.) ID tubing with a probe liner, stainless steel 9.53-mm (3/8-in.) ID stainless steel recycle tubing, two 6.35-mm (1/4-in.) ID stainless steel tubing for the pitot tube extensions, three thermocouple leads, and one power lead, all contained by stainless steel tubing with a diameter of approximately 51 mm (2.0 in.). Design considerations should include minimum weight construction materials sufficient for probe structural strength. Wrap the sample and recycle tubes with a heating tape to heat the sample and recycle gases to stack temperature.

2.1.6 Condenser. Same as in Method 5, Section 2.1.7.

2.1.7 Umbilical Connector. Flexible tubing with thermocouple and power leads of sufficient length to connect probe to meter and flow control console.

2.1.8 Vacuum Pump. Leak-tight, oil-less, noncontaminating, with an absolute filter, "HEPA" type, at the pump exit. A Gast Model 0522-V103 G18DX pump has been found to be satisfactory.

2.1.9 Meter and Flow Control Console. System consisting of a dry gas meter and calibrated orifice for measuring sample flow rate and capable of measuring volume to ± 2 percent, calibrated laminar flow elements (LFE's) or equivalent for measuring total and sample flow rates, probe heater control, and manometers and magnehelic gauges (as shown in Figures 4 and 5 of this method), or equivalent. Temperatures needed for calculations include stack, recycle, probe, dry gas meter, filter, and total flow. Flow measurements include velocity head (Δp), orifice differential pressure (ΔH), total flow, recycle flow, and total back-pressure through the system.

2.1.10 Barometer. Same as in Method 5, Section 2.1.9.

2.1.11 Rubber Tubing. 6.35-mm (1/4-in.) ID flexible rubber tubing.

2.2 Sample Recovery.

2.2.1 Nozzle, Cyclone, and Filter Holder Brushes. Nylon bristle brushes properly sized and shaped for cleaning the nozzle, cyclone, filter holder, and probe or probe liner, with stainless steel wire shafts and handles.

2.2.2 Wash Bottles, Glass Sample Storage Containers, Petri Dishes, Graduated Cylinder and Balance, Plastic Storage Containers, and Funnels. Same as Method 5, Sections 2.2.2 through 2.2.6 and 2.2.8, respectively.

2.3 Analysis. Same as in Method 5, Section 2.3.

3. Reagents

The reagents used in sampling, sample recovery, and analysis are the same as that specified in Method 5, Sections 3.1, 3.2, and 3.3, respectively.

4. Procedure

4.1 Sampling. The complexity of this method is such that, in order to obtain reliable results, testers should be trained and experienced with the test procedures.

4.1.1 Pretest Preparation. Same as in Method 5, Section 4.1.1.

4.1.2 Preliminary Determinations. Same as Method 5, Section 4.1.2, except use the directions on nozzle size selection in this section. Use of the EGR method may require a minimum sampling port diameter of 0.2 m (6 in.). Also, the required maximum number of sample traverse points at any location shall be 12.

4.1.2.1 The cyclone and filter holder must be in-stack or at stack temperature during sampling. The blockage effects of the EGR sampling assembly will be minimal if the cross-sectional area of the sampling assembly is 3 percent or less of the cross-sectional area of the duct and a pitot coefficient of 0.84 may be assigned to the pitot. If the cross-sectional area of the assembly is greater than 3 percent of the cross-sectional area of the duct, then either determine the pitot coefficient at sampling conditions or use a standard pitot with a known coefficient in a configuration with the EGR sampling assembly such that flow disturbances are minimized.

4.1.2.2 Construct a setup of pressure drops for various Δp 's and temperatures. A computer is useful for these calculations. An example of the output of the EGR setup program is shown in Figure 6 of this method, and directions on its use are in section 4.1.5.2 of this method. Computer programs, written in IBM BASIC computer language, to do these types of setup and reduction calculations for the EGR procedure, are available through the National Technical Information Services (NTIS), Accession number PB90-

500000, 5285 Port Royal Road, Springfield, VA 22161.

4.1.2.3 The EGR setup program allows the tester to select the nozzle size based on anticipated average stack conditions and prints a setup sheet for field use. The amount of recycle through the nozzle should be between 10 and 80 percent. Inputs for the EGR setup program are stack temperature (minimum, maximum, and average), stack velocity (minimum, maximum, and average), atmospheric pressure, stack static pressure, meter box temperature, stack moisture, percent O₂, and percent CO₂ in the stack gas, pitot coefficient (C_p), orifice Δ H₂, flow rate measurement calibration values [slope (m) and y-intercept (b) of the calibration curve], and the number of nozzles available and their diameters.

4.1.2.4 A less rigorous calculation for the setup sheet can be done manually using the equations on the example worksheets in Figures 7, 8, and 9 of this method, or by a Hewlett-Packard HP41 calculator using the program provided in appendix D of the EGR operators manual, entitled *Applications Guide for Source PM₁₀ Exhaust Gas Recycle Sampling System*. This calculation uses an approximation of the total flow rate and agrees within 1 percent of the exact solution for pressure drops at stack temperatures from 38 to 260 °C (100 to 500 °F) and stack moisture up to 50 percent. Also, the example worksheets use a constant stack temperature in the calculation, ignoring the complicated temperature dependence from all three pressure drop equations. Errors for this at stack temperatures ±28 °C (±50 °F) of the temperature used in the setup calculations are within 5 percent for flow rate and within 5 percent for cyclone cut size.

4.1.2.5 The pressure upstream of the LFE's is assumed to be constant at 0.6 in. Hg in the EGR setup calculations.

4.1.2.6 The setup sheet constructed using this procedure shall be similar to Figure 6 of this method. Inputs needed for the calculation are the same as for the setup computer except that stack velocities are not needed.

4.1.3 Preparation of Collection Train. Same as in Method 5, Section 4.1.3, except use the following directions to set up the train.

4.1.3.1 Assemble the EGR sampling device, and attach it to probe as shown in Figure 3 of this method. If stack temperatures exceed 260 °C (500 °F), then assemble the EGR cyclone without the O-ring and reduce the vacuum requirement to 130 mm Hg (5.0 in. Hg) in the leak-check procedure in Section 4.1.4.3.2 of this method.

4.1.3.2 Connect the probe directly to the filter holder and condenser as in Method 5. Connect the condenser and probe to the meter and flow control console with the umbilical connector. Plug in the pump and attach pump lines to the meter and flow control console.

4.1.4 Leak-Check Procedure. The leak-check for the EGR Method consists of two parts: the sample-side and the recycle-side. The sample-side leak-check is required at the beginning of the run with the cyclone attached, and after the run with the cyclone removed. The cyclone is removed before the post-test leak-check to prevent any disturbance of the collected sample prior to analysis. The recycle-side leak-check tests the leak tight integrity of the recycle components and is required prior to the first test run and after each shipment.

4.1.4.1 Pretest Leak-Check. A pretest leak-check of the entire sample-side, including the cyclone and nozzle, is required. Use the leak-check procedure in Section 4.1.4.3 of this method to conduct a pretest leak-check.

4.1.4.2 Leak-Checks During Sample Run. Same as in Method 5, Section 4.1.4.1.

4.1.4.3 Post-Test Leak-Check. A leak-check is required at the conclusion of each sampling run. Remove the cyclone before the leak-check to prevent the vacuum created by the cooling of the probe from disturbing the collected sample and use the following procedure to conduct a post-test leak-check.

4.1.4.3.1 The sample-side leak-check is performed as follows: After removing the cyclone, seal the probe with a leak-tight stopper. Before starting pump, close the coarse total valve and both recycle valves, and open completely the sample back pressure valve and the fine total valve. After turning the pump on, partially open the coarse total valve slowly to prevent a surge in the manometer. Adjust the vacuum to at least 381 mm Hg (15.0 in. Hg) with the fine total valve. If the desired vacuum is exceeded, either leak-check at this higher vacuum or end the leak-check as shown below and start over.

CAUTION: Do not decrease the vacuum with any of the valves. This may cause a rupture of the filter.

NOTE: A lower vacuum may be used, provided that it is not exceeded during the test.

4.1.4.3.2 Leak rates in excess of 0.00057 m³/min (0.020 ft³/min) are unacceptable. If the leak rate is too high, void the sampling run.

4.1.4.3.3 To complete the leak-check, slowly remove the stopper from the nozzle until the vacuum is near zero, then immediately turn off the pump. This procedure sequence prevents a pressure surge in the manometer fluid and rupture of the filter.

4.1.4.3.4 The recycle-side leak-check is performed as follows: Close the coarse and fine total valves and sample back pressure valve. Plug the sample inlet at the meter box. Turn on the power and the pump, close the recycle valves, and open the total flow valves. Adjust the total flow fine adjust valve until a vacuum of 25 inches of mercury is achieved. If the desired vacuum is exceeded, either leak-check at this higher vacuum, or end the

leak-check and start over. Minimum acceptable leak rates are the same as for the sample-side. If the leak rate is too high, void the sampling run.

4.1.5 EGR Train Operation. Same as in Method 5, Section 4.1.5, except omit references to nomographs and recommendations about changing the filter assembly during a run.

4.1.5.1 Record the data required on a data sheet such as the one shown in Figure 10 of this method. Make periodic checks of the manometer level and zero to ensure correct ΔH and Δp values. An acceptable procedure for checking the zero is to equalize the pressure at both ends of the manometer by pulling off the tubing, allowing the fluid to equilibrate and, if necessary, to re-zero. Maintain the probe temperature to within 11 °C (20 °F) of stack temperature.

4.1.5.2 The procedure for using the example EGR setup sheet is as follows: Obtain a stack velocity reading from the pitot manometer (Δp), and find this value on the ordinate axis of the setup sheet. Find the stack temperature on the abscissa. Where these two values intersect are the differential pressures necessary to achieve isokineticity and 10 μm cut size (interpolation may be necessary).

4.1.5.3 The top three numbers are differential pressures (in. H₂O), and the bottom number is the percent recycle at these flow settings. Adjust the total flow rate valves, coarse and fine, to the sample value (ΔH) on the setup sheet, and the recycle flow rate valves, coarse and fine, to the recycle flow on the setup sheet.

4.1.5.4 For startup of the EGR sample train, the following procedure is recommended. Preheat the cyclone in the stack for 30 minutes. Close both the sample and recycle coarse valves. Open the fine total, fine recycle, and sample back pressure valves halfway. Ensure that the nozzle is properly aligned with the sample stream. After noting the Δp and stack temperature, select the appropriate ΔH and recycle from the EGR setup sheet. Start the pump and timing device simultaneously. Immediately open both the coarse total and the coarse recycle valves slowly to obtain the approximate desired values. Adjust both the fine total and the fine recycle valves to achieve more precisely the desired values. In the EGR flow system, adjustment of either valve will result in a change in both total and recycle flow rates, and a slight iteration between the total and recycle valves may be necessary. Because the sample back pressure valve controls the total flow rate through the system, it may be necessary to adjust this valve in order to obtain the correct flow rate.

NOTE: Isokinetic sampling and proper operation of the cyclone are not achieved unless the correct ΔH and recycle flow rates are maintained.

4.1.5.5 During the test run, monitor the probe and filter temperatures periodically, and make adjustments as necessary to maintain the desired temperatures. If the sample loading is high, the filter may begin to blind or the cyclone may clog. The filter or the cyclone may be replaced during the sample run. Before changing the filter or cyclone, conduct a leak-check (Section 4.1.4.2 of this method). The total particulate mass shall be the sum of all cyclone and the filter catch during the run. Monitor stack temperature and Δp periodically, and make the necessary adjustments in sampling and recycle flow rates to maintain isokinetic sampling and the proper flow rate through the cyclone. At the end of the run, turn off the pump, close the coarse total valve, and record the final dry gas meter reading. Remove the probe from the stack, and conduct a post-test leak-check as outlined in Section 4.1.4.3 of this method.

4.2 Sample Recovery. Allow the probe to cool. When the probe can be safely handled, wipe off all external PM adhering to the outside of the nozzle, cyclone, and nozzle attachment, and place a cap over the nozzle to prevent losing or gaining PM. Do not cap the nozzle tip tightly while the sampling train is cooling, as this action would create a vacuum in the filter holder. Disconnect the probe from the umbilical connector, and take the probe to the cleanup site. Sample recovery should be conducted in a dry indoor area or, if outside, in an area protected from wind and free of dust. Cap the ends of the impingers and carry them to the cleanup site. Inspect the components of the train prior to and during disassembly to note any abnormal conditions. Disconnect the pitot from the cyclone. Remove the cyclone from the probe. Recover the sample as follows:

4.2.1 *Container Number 1 (Filter)*. The recovery shall be the same as that for Container Number 1 in Method 5, Section 4.2.

4.2.2 *Container Number 2 (Cyclone or Large PM Catch)*. The cyclone must be disassembled and the nozzle removed in order to recover the large PM catch. Quantitatively recover the PM from the interior surfaces of the nozzle and the cyclone, excluding the “turn around” cup and the interior surfaces of the exit tube. The recovery shall be the same as that for Container Number 2 in Method 5, Section 4.2.

4.2.3 *Container Number 3 (PM₁₀)*. Quantitatively recover the PM from all of the surfaces from cyclone exit to the front half of the in-stack filter holder, including the “turn around” cup and the interior of the exit tube. The recovery shall be the same as that for Container Number 2 in Method 5, Section 4.2.

4.2.4 *Container Number 4 (Silica Gel)*. Same as that for Container Number 3 in Method 5, Section 4.2.

4.2.5 *Impinger Water*. Same as in Method 5, Section 4.2, under "Impinger Water."

4.3 *Analysis*. Same as in Method 5, Section 4.3, except handle EGR Container Numbers 1 and 2 like Container Number 1 in Method 5, EGR Container Numbers 3, 4, and 5 like Container Number 3 in Method 5, and EGR Container Number 6 like Container Number 3 in Method 5. Use Figure 11 of this method to record the weights of PM collected.

4.4 *Quality Control Procedures*. Same as in Method 5, Section 4.4.

4.5 *PM₁₀ Emission Calculation and Acceptability of Results*. Use the EGR reduction program or the procedures in section 6 of this method to calculate PM₁₀ emissions and the criteria in section 6.7 of this method to determine the acceptability of the results.

5. Calibration

Maintain an accurate laboratory log of all calibrations.

5.1 *Probe Nozzle*. Same as in Method 5, Section 5.1.

5.2 *Pitot Tube*. Same as in Method 5, Section 5.2.

5.3 *Meter and Flow Control Console*.

5.3.1 *Dry Gas Meter*. Same as in Method 5, Section 5.3.

5.3.2 *LFE Gauges*. Calibrate the recycle, total, and inlet total LFE gauges with a manometer. Read and record flow rates at 10, 50, and 90 percent of full scale on the total and recycle pressure gauges. Read and record flow rates at 10, 20, and 30 percent of full scale on the inlet total LFE pressure gauge. Record the total and recycle readings to the nearest 0.3 mm (0.01 in.). Record the inlet total LFE readings to the nearest 3 mm (0.1 in.). Make three separate measurements at each setting and calculate the average. The maximum difference between the average pressure reading and the average manometer reading shall not exceed 1 mm (0.05 in.). If the differences exceed the limit specified, adjust or replace the pressure gauge. After each field use, check the calibration of the pressure gauges.

5.3.3 *Total LFE*. Same as the metering system in Method 5, Section 5.3.

5.3.4 *Recycle LFE*. Same as the metering system in Method 5, Section 5.3, except completely close both the coarse and fine recycle valves.

5.4 *Probe Heater*. Connect the probe to the meter and flow control console with the umbilical connector. Insert a thermocouple into the probe sample line approximately half the length of the probe sample line. Calibrate the probe heater at 66°C (150°F), 121°C (250°F), and 177°C (350°F). Turn on the power, and set the probe heater to the specified temperature. Allow the heater to equilibrate, and record the thermocouple temperature and the meter and flow control console temperature to the nearest 0.5°C (1°F). The two temperatures should agree within 5.5°C

(10°F). If this agreement is not met, adjust or replace the probe heater controller.

5.5 *Temperature Gauges*. Connect all thermocouples, and let the meter and flow control console equilibrate to ambient temperature. All thermocouples shall agree to within 1.1°C (2.0°F) with a standard mercury-in-glass thermometer. Replace defective thermocouples.

5.6 *Barometer*. Calibrate against a standard mercury-in-glass barometer.

5.7 *Probe Cyclone and Nozzle Combinations*. The probe cyclone and nozzle combinations need not be calibrated if the cyclone meets the design specifications in Figure 12 of this method and the nozzle meets the design specifications in appendix B of the *Application Guide for the Source PM_{3.0} Exhaust Gas Recycle Sampling System*, EPA/600/3-88-058. This document may be obtained from Roy Huntley at (919) 541-1060. If the nozzles do not meet the design specifications, then test the cyclone and nozzle combination for conformity with the performance specifications (PS's) in Table 1 of this method. The purpose of the PS tests is to determine if the cyclone's sharpness of cut meets minimum performance criteria. If the cyclone does not meet design specifications, then, in addition to the cyclone and nozzle combination conforming to the PS's, calibrate the cyclone and determine the relationship between flow rate, gas viscosity, and gas density. Use the procedures in Section 5.7.5 of this method to conduct PS tests and the procedures in Section 5.8 of this method to calibrate the cyclone. Conduct the PS tests in a wind tunnel described in Section 5.7.1 of this method and using a particle generation system described in Section 5.7.2 of this method. Use five particle sizes and three wind velocities as listed in Table 2 of this method. Perform a minimum of three replicate measurements of collection efficiency for each of the 15 conditions listed, for a minimum of 45 measurements.

5.7.1 *Wind Tunnel*. Perform calibration and PS tests in a wind tunnel (or equivalent test apparatus) capable of establishing and maintaining the required gas stream velocities within 10 percent.

5.7.2 *Particle Generation System*. The particle generation system shall be capable of producing solid monodispersed dye particles with the mass median aerodynamic diameters specified in Table 2 of this method. The particle size distribution verification should be performed on an integrated sample obtained during the sampling period of each test. An acceptable alternative is to verify the size distribution of samples obtained before and after each test, with both samples required to meet the diameter and monodispersity requirements for an acceptable test run.

5.7.2.1 *Establish the size of the solid dye particles delivered to the test section of the*

wind tunnel using the operating parameters of the particle generation system, and verify the size during the tests by microscopic examination of samples of the particles collected on a membrane filter. The particle size, as established by the operating parameters of the generation system, shall be within the tolerance specified in Table 2 of this method. The precision of the particle size verification technique shall be at least ± 0.5 μm , and the particle size determined by the verification technique shall not differ by more than 10 percent from that established by the operating parameters of the particle generation system.

5.7.2.2 Certify the monodispersity of the particles for each test either by microscopic inspection of collected particles on filters or by other suitable monitoring techniques such as an optical particle counter followed by a multichannel pulse height analyzer. If the proportion of multiplets and satellites in an aerosol exceeds 10 percent by mass, the particle generation system is unacceptable for purposes of this test. Multiplets are particles that are agglomerated, and satellites are particles that are smaller than the specified size range.

5.7.3 Schematic Drawings. Schematic drawings of the wind tunnel and blower system and other information showing complete procedural details of the test atmosphere generation, verification, and delivery techniques shall be furnished with calibration data to the reviewing agency.

5.7.4 Flow Rate Measurement. Determine the cyclone flow rates with a dry gas meter and a stopwatch, or a calibrated orifice sys-

tem capable of measuring flow rates to within 2 percent.

5.7.5 Performance Specification Procedure. Establish the test particle generator operation and verify the particle size microscopically. If monodispersity is to be verified by measurements at the beginning and the end of the run rather than by an integrated sample, these measurements may be made at this time.

5.7.5.1 The cyclone cut size (D_{50}) is defined as the aerodynamic diameter of a particle having a 50 percent probability of penetration. Determine the required cyclone flow rate at which D_{50} is 10 μm . A suggested procedure is to vary the cyclone flow rate while keeping a constant particle size of 10 μm . Measure the PM collected in the cyclone (m_c), exit tube (m_t), and filter (m_f). Compute the cyclone efficiency (E_c) as follows:

$$E_c = \frac{m_c}{(m_c + m_t + m_f)} \times 100$$

5.7.5.2 Perform three replicates and calculate the average cyclone efficiency as follows:

$$E_{\text{avg}} = \frac{(E_1 + E_2 + E_3)}{3}$$

where E_1 , E_2 , and E_3 are replicate measurements of E_c .

5.7.5.3 Calculate the standard deviation (σ) for the replicate measurements of E_c as follows:

$$\sigma = \left[\frac{(E_1^2 + E_2^2 + E_3^2) - \frac{(E_1 + E_2 + E_3)^2}{3}}{2} \right]^{\frac{1}{2}}$$

if σ exceeds 0.10, repeat the replicate runs.

5.7.5.4 Using the cyclone flow rate that produces D_{50} for 10 μm , measure the overall efficiency of the cyclone and nozzle, E_o , at the particle sizes and nominal gas velocities in Table 2 of this method using this following procedure.

5.7.5.5 Set the air velocity in the wind tunnel to one of the nominal gas velocities from Table 2 of this method. Establish isokinetic sampling conditions and the correct flow rate through the sampler (cyclone and nozzle) using recycle capacity so that the D_{50} is 10 μm . Sample long enough to ob-

tain ± 5 percent precision on the total collected mass as determined by the precision and the sensitivity of the measuring technique. Determine separately the nozzle catch (m_n), cyclone catch (m_c), cyclone exit tube catch (m_t), and collection filter catch (m_f).

5.7.5.6 Calculate the overall efficiency (E_o) as follows:

$$E_o = \frac{(m_n + m_c)}{(m_n + m_c + m_t + m_f)} \times 100$$

5.7.5.7 Do three replicates for each combination of gas velocities and particle sizes in Table 2 of this method. Calculate E_o for each particle size following the procedures described in this section for determining efficiency. Calculate the standard deviation (σ) for the replicate measurements. If σ exceeds 0.10, repeat the replicate runs.

5.7.6 Criteria for Acceptance. For each of the three gas stream velocities, plot the average E_o as a function of particle size on Figure 13 of this method. Draw a smooth curve for each velocity through all particle sizes. The curve shall be within the banded region for all sizes, and the average E_o for a D_{50} for 10 μm shall be 50 ± 0.5 percent.

5.8 Cyclone Calibration Procedure. The purpose of this section is to develop the relationship between flow rate, gas viscosity, gas density, and D_{50} . This procedure only needs to be done on those cyclones that do not meet the design specifications in Figure 12 of this method.

5.8.1 Calculate cyclone flow rate. Determine the flow rates and D_{50} 's for three different particle sizes between 5 μm and 15 μm , one of which shall be 10 μm . All sizes must be within 0.5 μm . For each size, use a different temperature within 60 °C (108 °F) of the temperature at which the cyclone is to be used and conduct triplicate runs. A suggested procedure is to keep the particle size constant and vary the flow rate. Some of the values

obtained in the PS tests in Section 5.7.5 may be used.

5.8.1.1 On log-log graph paper, plot the Reynolds number (Re) on the abscissa, and the square root of the Stokes 50 number $[(\text{Stk}_{50})^{1/2}]$ on the ordinate for each temperature. Use the following equations:

$$\text{Re} = \frac{4\rho Q_{\text{cyc}}}{d_{\text{cyc}} \pi \mu_{\text{cyc}}}$$

$$(\text{Stk}_{50})^{1/2} = \left[\frac{4Q_{\text{cyc}} (D_{50})^2}{9\pi \mu_{\text{cyc}} (d_{\text{cyc}})^3} \right]^{1/2}$$

where:

Q_{cyc} = Cyclone flow rate cm^3/sec .

ρ = Gas density, g/cm^3 .

d_{cyc} = Diameter of cyclone inlet, cm .

μ_{cyc} = Viscosity of gas through the cyclone, poise.

D_{50} = Cyclone cut size, cm .

5.8.1.2 Use a linear regression analysis to determine the slope (m), and the y-intercept (b). Use the following formula to determine Q, the cyclone flow rate required for a cut size of 10 μm .

$$Q = \frac{\pi \mu_{\text{cyc}}}{4} \left[(3000)(K_1)^b \right] - (0.5 - m) \left[\frac{T_s}{M_c P_s} \right] m / (m - 0.5)^{(m-1.5)/(m-0.5)}$$

where:

Q = Cyclone flow rate for a cut size of 10 μm , cm^3/sec .

T_s = Stack gas temperature, °K.

d = Diameter of nozzle, cm .

$K_1 = 4.077 \times 10^{-3}$.

5.8.2. Directions for Using Q. Refer to Section 5 of the EGR operators manual for directions in using this expression for Q in the setup calculations.

6. Calculations

6.1 The EGR data reduction calculations are performed by the EGR reduction computer program, which is written in IBM BASIC computer language and is available through NTIS, Accession number PB90-500000, 5285 Port Royal Road, Springfield, Virginia 22161. Examples of program inputs and outputs are shown in Figure 14 of this method.

6.1.1 Calculations can also be done manually, as specified in Method 5, Sections 6.3

through 6.7, and 6.9 through 6.12, with the addition of the following:

6.1.2 Nomenclature.

B_c = Moisture fraction of mixed cyclone gas, by volume, dimensionless.

C_1 = Viscosity constant, 51.12 micropoise for °K (51.05 micropoise for °R).

C_2 = Viscosity constant, 0.372 micropoise/°K (0.207 micropoise/°R).

C_3 = Viscosity constant, 1.05×10^{-4} micropoise/°K² (3.24×10^{-5} micropoise/°R²).

C_4 = Viscosity constant, 53.147 micropoise/fraction O₂.

C_5 = Viscosity constant, 74.143 micropoise/fraction H₂ O.

D_{50} = Diameter of particles having a 50 percent probability of penetration, μm .

f_{O_2} = Stack gas fraction O₂ by volume, dry basis.

$K_1 = 0.3858$ °K/mm Hg (17.64 °R/in. Hg).

M_c = Wet molecular weight of mixed gas through the PM₁₀ cyclone, g/g-mole (lb/lb-mole).

M_d = Dry molecular weight of stack gas, g/g-mole (lb/lb-mole).

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P_{bar} = Barometer pressure at sampling site, mm Hg (in. Hg).

P_{in1} = Gauge pressure at inlet to total LFE, mm H₂O (in. H₂O).

P_3 = Absolute stack pressure, mm Hg (in. Hg).

Q_2 = Total cyclone flow rate at wet cyclone conditions, m³/min (ft³/min).

$Q_{\text{s(std)}}$ = Total cyclone flow rate at standard conditions, dscm/min (dscf/min).

T_m = Average temperature of dry gas meter, °K (°R).

T_s = Average stack gas temperature, °K (°R).

$V_{\text{w(std)}}$ = Volume of water vapor in gas sample (standard conditions), scm (scf).

X_T = Total LFE linear calibration constant, m³/[(min)(mm H₂O)] { ft³/[(min)(in. H₂O)]}.

Y_T = Total LFE linear calibration constant, dscm/min (dscf/min).

ΔP_T = Pressure differential across total LFE, mm H₂O, (in. H₂O).

θ = Total sampling time, min.

μ_{cyc} = Viscosity of mixed cyclone gas, micropoise.

μ_{LFE} = Viscosity of gas laminar flow elements, micropoise.

μ_{std} = Viscosity of standard air, 180.1 micropoise.

6.2 PM₁₀ Particulate Weight. Determine the weight of PM₁₀ by summing the weights obtained from Container Numbers 1 and 3, less the acetone blank.

6.3 Total Particulate Weight. Determine the particulate catch for PM greater than PM₁₀ from the weight obtained from Container Number 2 less the acetone blank, and add it to the PM₁₀ particulate weight.

6.4 PM₁₀ Fraction. Determine the PM₁₀ fraction of the total particulate weight by dividing the PM₁₀ particulate weight by the total particulate weight.

6.5 Total Cyclone Flow Rate. The average flow rate at standard conditions is determined from the average pressure drop across the total LFE and is calculated as follows:

$$Q_{\text{s(std)}} = K_1 \left[X_T \Delta P \frac{\mu_{\text{std}}}{\mu_{\text{LFE}}} + Y_T \right] \frac{P_{\text{bar}} + P_{\text{in1}}/13.6}{T_m}$$

The flow rate, at actual cyclone conditions, is calculated as follows:

$$Q_s = \frac{T_s}{K_1 P_s} \left[Q_{\text{s(std)}} + \frac{V_{\text{w(std)}}}{\theta} \right]$$

The flow rate, at actual cyclone conditions, is calculated as follows:

$$Q_s = \frac{T_s}{K_1 P_s} \left[Q_{\text{s(std)}} + \frac{V_{\text{w(std)}}}{\theta} \right]$$

6.6 Aerodynamic Cut Size. Use the following procedure to determine the aerodynamic cut size (D_{50}).

6.6.1 Determine the water fraction of the mixed gas through the cyclone by using the equation below.

$$B_c = \frac{V_{\text{w(std)}}}{Q_{\text{s(std)}} \theta + V_{\text{w(std)}}}$$

6.6.2 Calculate the cyclone gas viscosity as follows:

$$\mu_{\text{cyc}} = C_1 + C_2 T_s + C_3 T_s^2 + C_4 f_{02} - C_5 B_c$$

6.6.3 Calculate the molecular weight on a wet basis of the cyclone gas as follows:

$$M_c = M_d(1 - B_c) + 18.0(B_c)$$

6.6.4 If the cyclone meets the design specification in Figure 12 of this method, calculate the actual D_{50} of the cyclone for the run as follows:

$$D_{50} = \beta_1 \left[\frac{T_s}{M_c P_s} \right] \frac{0.2.091}{\left[\frac{\mu_{\text{cyc}}}{Q_s} \right]} \frac{0.7091}{\left[\frac{\mu_{\text{cyc}}}{Q_s} \right]}$$

where $\beta_1 = 0.1562$.

6.6.5 If the cyclone does not meet the design specifications in Figure 12 of this method, then use the following equation to calculate D_{50} .

$$D_{50} = (3) (10)^b \left(7.376 \times 10^{-4} \right)^m \left[\frac{M_c P_s}{T_s} \right] \left[\frac{4 Q_s}{\pi \mu_{cyc}} \right] d^{(1.5-m)}$$

where:

m = Slope of the calibration curve obtained in Section 5.8.2.

b = y-intercept of the calibration curve obtained in Section 5.8.2.

6.7 Acceptable Results. Acceptability of anisokinetic variation is the same as Method 5, Section 6.12.

6.7.1 If $9.0 \mu\text{m} \leq D_{50} \leq 11 \mu\text{m}$ and $90 \leq I \leq 110$, the results are acceptable. If D_{50} is greater than $11 \mu\text{m}$, the Administrator may accept the results. If D_{50} is less than $9.0 \mu\text{m}$, reject the results and repeat the test.

7. Bibliography

1. Same as Bibliography in Method 5.

2. McCain, J.D., J.W. Ragland, and A.D. Williamson. Recommended Methodology for the Determination of Particles Size Distributions in Ducted Sources, Final Report. Prepared for the California Air Resources Board by Southern Research Institute. May 1986.

3. Farthing, W.E., S.S. Dawes, A.D. Williamson, J.D. McCain, R.S. Martin, and J.W. Ragland. Development of Sampling Methods for Source PM-10 Emissions. Southern Research Institute for the Environmental Protection Agency. April 1989.

4. *Application Guide for the Source PM₁₀ Exhaust Gas Recycle Sampling System*, EPA/600/3-88-058.

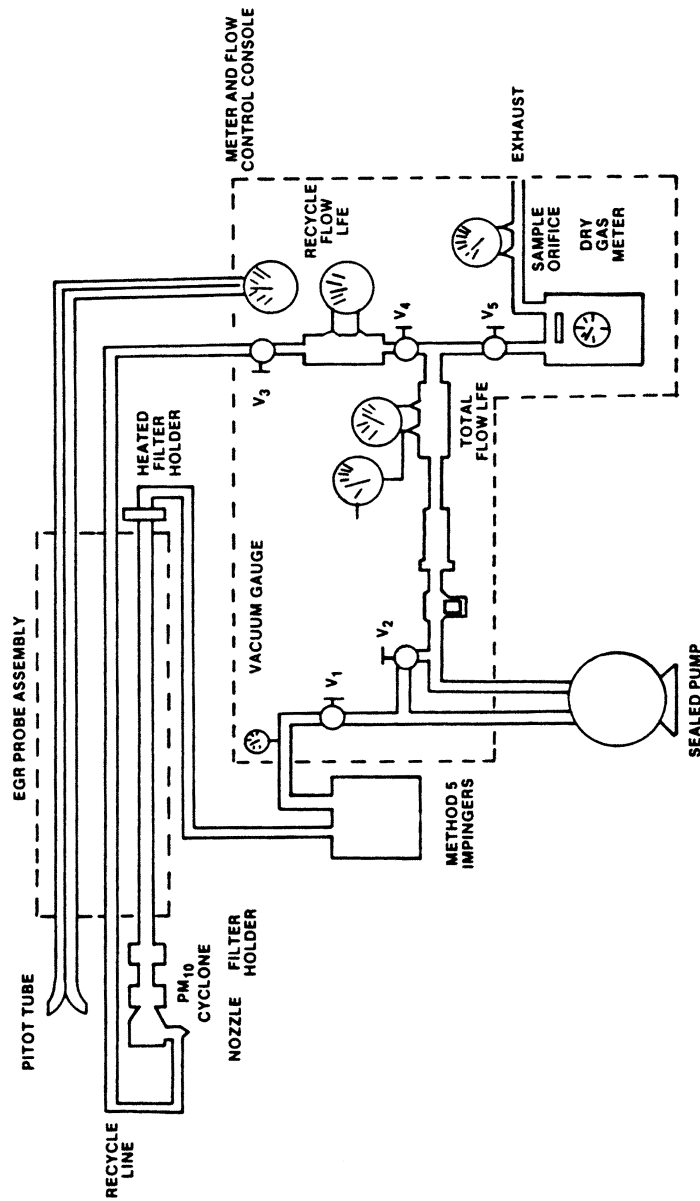


Figure 1. Schematic of the exhaust gas recycle train.

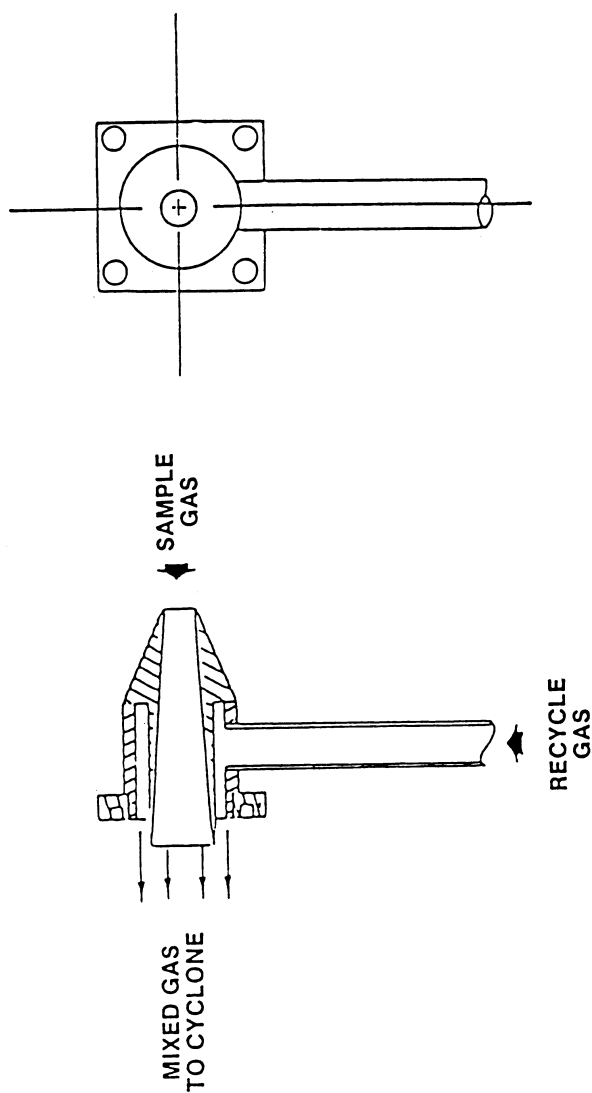


Figure 2. Schematic of EGR nozzle assembly.

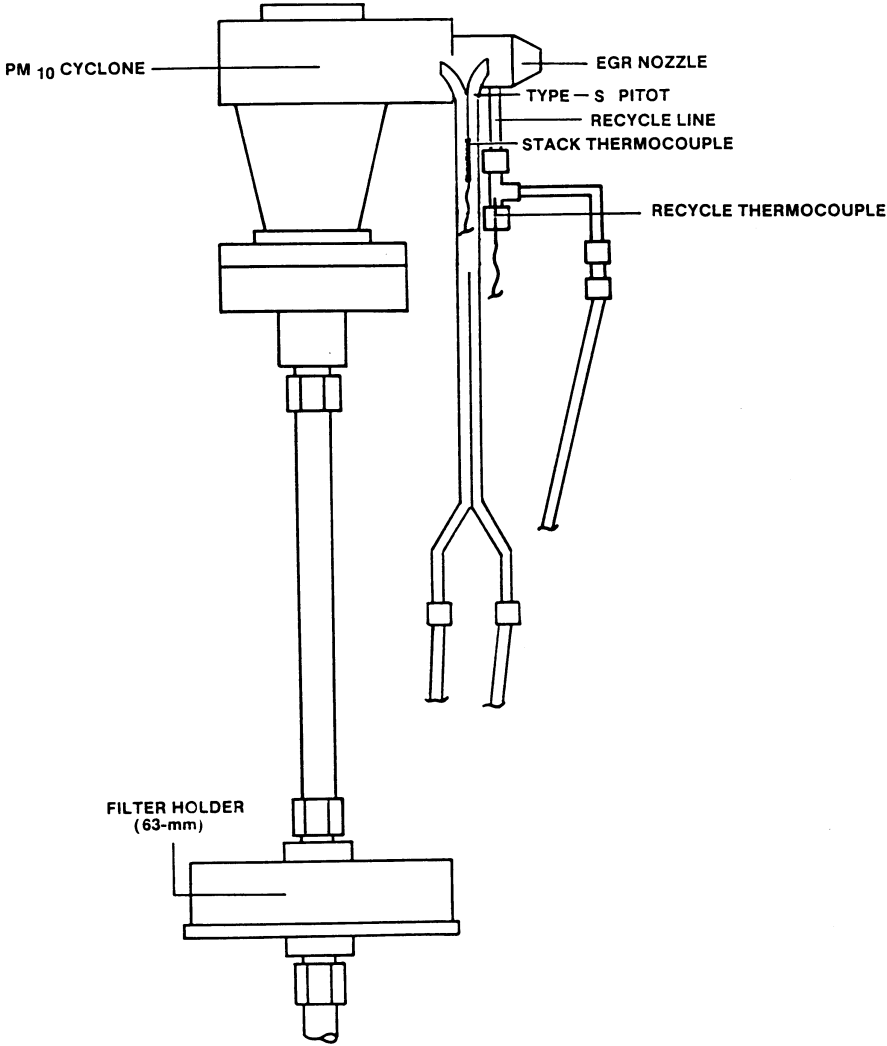


Figure 3. EGR PM₁₀ cyclone sampling device.

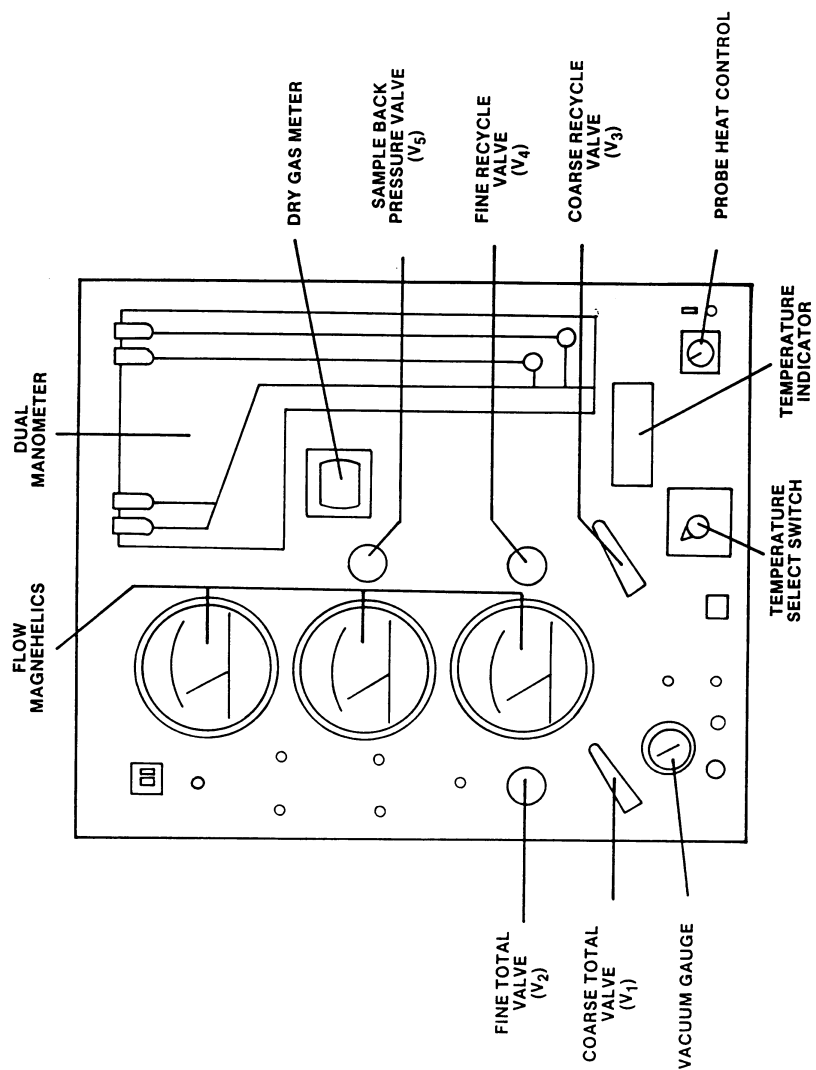


Figure 4. Example EGR control module (front view) showing principle components.

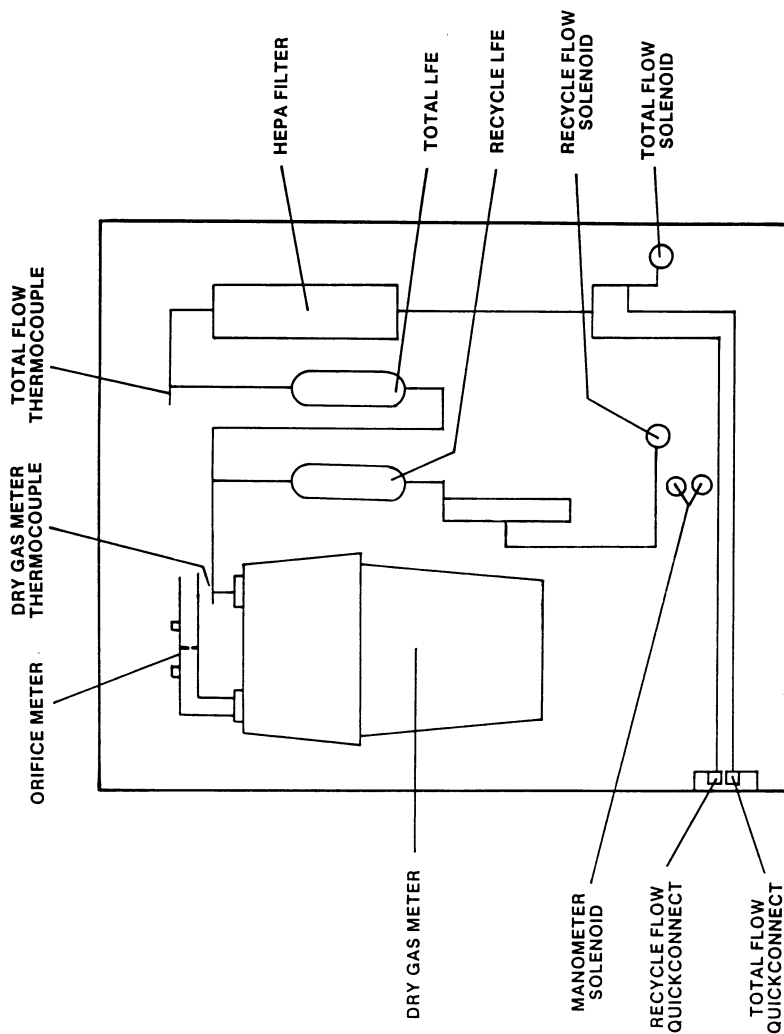


Figure 5. Example EGR control module (rear view) showing principle components.

EXAMPLE EMISSION GAS RECYCLE
SETUP SHEET

VERSION 3.1 MAY 1986

TEST I.D.: SAMPLE SETUP

RUN DATE: 11/24/86

LOCATION: SOURCE SIM

OPERATOR(S): RH JB

NOZZLE DIAMETER (IN): .25

STACK CONDITIONS:

AVERAGE TEMPERATURE (F): 200.0

AVERAGE VELOCITY (FT/SEC): 15.0

AMBIENT PRESSURE (IN HG): 29.92

STACK PRESSURE (IN H₂O): .10

GAS COMPOSITION:

H₂O=10.0%.....MD=28.84

O₂=20.9%MW=27.75

CO₂=0%.....(LB/LB MOLE)

TARGET PRESSURE DROPS

TEMPERATURE (F)

| | | | | | | | | |
|-------------|--------|-----|-----|-----|-----|-----|-----|-----|
| DP(PTO) .. | 150 | 161 | 172 | 183 | 194 | 206 | 217 | 228 |
| 0.026 | SAMPLE | .49 | .49 | .48 | .47 | .46 | .45 | .45 |

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| | | | | | | | | |
|------------|---------|------|------|------|------|------|------|------|
| | TOTAL | 1.90 | 1.90 | 1.91 | 1.92 | 1.92 | 1.92 | 1.93 |
| | RECYCLE | 2.89 | 2.92 | 2.94 | 2.97 | 3.00 | 3.02 | 3.05 |
| | % RCL | 61% | 61% | 62% | 62% | 63% | 63% | 63% |
| .031 | .58 | .56 | .55 | .55 | .55 | .54 | .53 | .52 |
| | 1.88 | 1.89 | 1.89 | 1.90 | 1.91 | 1.91 | 1.91 | 1.92 |
| | 2.71 | 2.74 | 2.77 | 2.80 | 2.82 | 2.85 | 2.88 | 2.90 |
| | 57% | 57% | 58% | 58% | 59% | 59% | 60% | 60% |
| .035 | .67 | .65 | .64 | .63 | .62 | .61 | .670 | .59 |
| | 1.88 | 1.88 | 1.89 | 1.89 | 1.90 | 1.90 | 1.91 | 1.91 |
| | 2.57 | 2.60 | 2.63 | 2.66 | 2.69 | 2.72 | 2.74 | 2.74 |
| | 54% | 55% | 55% | 56% | 56% | 57% | 57% | 57% |
| .039 | .75 | .74 | .72 | .71 | .70 | .69 | .67 | .66 |
| | 1.87 | 1.88 | 1.88 | 1.89 | 1.89 | 1.90 | 1.90 | 1.91 |
| | 2.44 | 2.47 | 2.50 | 2.53 | 2.56 | 2.59 | 2.62 | 2.65 |
| | 51% | 52% | 52% | 53% | 53% | 54% | 54% | 55% |

Figure 6. Example EGR setup sheet.

| | | | | | |
|---|---|-------|---|---|------------|
| Barometric pressure, P_{bar} , in. Hg. | = | _____ | ΔH_2 , in. H_2O | = | _____ |
| Stack static pressure, P_g , in. H_2O . | = | _____ | Molecular weight of stack gas, dry basis: | | |
| Average stack temperature, t_s , °F. | = | _____ | $M_d=0.44$ | | |
| Meter temperature, t_m , °F. | = | _____ | (%CO ₂)+0.32 | = | lb/lb mole |
| Gas analysis: | | | (%O ₂)+0.28 | | |
| %CO ₂ | = | _____ | (%N ₂ +%CO) | | |
| %O ₂ | = | _____ | Molecular weight of stack gas, wet basis: | | |
| %N ₂ +%CO | = | _____ | $M_w=M_d(1-B_{ws})+18B_{ws}$ | = | lb/lb mole |
| Fraction moisture content, B_{ws} . | = | _____ | Absolute stack pressure: | | |
| Calibration data: | | | $P_s=P_{bar}+(P_g/13.6)$ | = | in. Hg |
| Nozzle diameter, D_n in. | = | _____ | | | |
| Pitot coefficient, C_p . | = | _____ | | | |

$$K = 846.72 D_n^4 \Delta H_{@} C_p^2 (1-B_{ws})^2 \frac{M_d (t_m + 460) P_s}{M_w (t_s + 460) P_{bar}} = \underline{\hspace{2cm}}$$

Desired meter orifice pressure (ΔH) for velocity head of stack gas (Δp):

$$\Delta H = K \Delta p = \underline{\hspace{2cm}} \text{ in. } H_2O$$

Figure 7. Example worksheet 1, meter orifice pressure head calculation.

| | | | | | |
|---|---|-------|---|---|--------|
| Barometric pressure, P_{bar} , in. Hg. | = | _____ | Gas analysis: | | |
| Absolute stack pressure, P_s , in. Hg. | = | _____ | %O ₂ | = | _____ |
| Average stack temperature, T_s , °R. | = | _____ | Fraction moisture content, B_{ws} . | = | _____ |
| Meter temperature, T_m , °R. | = | _____ | Calibration data: | | |
| Molecular weight of stack gas, wet basis, M_d lb/lb mole. | = | _____ | Nozzle diameter, D_n , in. | = | _____ |
| Pressure upstream of LFE, in. Hg. | = | 0.6 | Pitot coefficient, C_p ... | = | _____ |
| | | | Total LFE calibration constant, X_i . | = | _____ |
| | | | Total LFE calibration constant, T_i . | = | _____ |
| | | | Absolute pressure upstream of LFE: | | |
| | | | $P_{LFE}=P_{bar}+0.6$ | = | in. Hg |

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Viscosity of gas in total

LFE:

$$\mu_{\text{LFE}} = 152.418 + 0.2552 T_m + 3.2355 \times 10^{-5} T_m^2 + 0.53147 (\% \text{O}_2).$$

Viscosity of dry stack

gas:

$$\mu_d = 152.418 + 0.2552 T_s + 3.2355 \times 10^{-5} T_s^2 + 0.53147 (\% \text{O}_2).$$

Constants:

$$K_1 = 1.5752 \times 10^{-5} \frac{\mu_{\text{LFE}} T_m P_s^{0.7051} \mu_d}{P_{\text{LFE}} M_d^{0.2949} T_s^{0.07051}} = \underline{\hspace{2cm}}$$

$$K_2 = 0.1539 \frac{\mu_{\text{LFE}} T_m D_n^2 C_p \left[\frac{P_s}{T_s} \right]^{\frac{1}{2}}}{P_{\text{LFE}}}$$

$$K_3 = \frac{B_{\text{ws}} \mu_d [1 - 0.2949(1 - 18/M_d)] + 74.143 B_{\text{ws}} (1 - B_{\text{ws}})}{\mu_d - 74.143 B_{\text{ws}}} = \underline{\hspace{2cm}}$$

$$A_1 = \frac{K_1}{X_t} - \frac{\mu_{\text{LFE}} Y_t}{180.1 X_t} = \underline{\hspace{2cm}}$$

$$B_1 = \frac{K_2 K_3}{(M_w)^{\frac{1}{2}} X_t} = \underline{\hspace{2cm}}$$

Total LFE pressure head:

$$\Delta p_t = A_1 - B_1 (\Delta p)^{\frac{1}{2}} = \underline{\hspace{2cm}} \text{ in. H}_2\text{O}$$

Figure 8. Example worksheet 1, meter orifice pressure head calculation.

Barometric pressure, P_{bar} , in. Hg. = $\underline{\hspace{2cm}}$

Absolute stack pressure, P_s , in. Hg. = $\underline{\hspace{2cm}}$

Average stack temperature, T_s , °R. = $\underline{\hspace{2cm}}$

Meter temperature, T_m , °R. = $\underline{\hspace{2cm}}$

Molecular weight of stack gas, dry basis, M_d lb/lb mole. = $\underline{\hspace{2cm}}$

Viscosity of LFE gas, μ_{LFE} , poise. = $\underline{\hspace{2cm}}$

Absolute pressure upstream of LFE, P_{LFE} , in. Hg. = $\underline{\hspace{2cm}}$

Calibration data: Nozzle diameter, D_n , in. = $\underline{\hspace{2cm}}$

Pitot coefficient, C_p ... = $\underline{\hspace{2cm}}$

Recycle LFE calibration constant, X_t = $\underline{\hspace{2cm}}$

Recycle LFE calibration constant, Y_t = $\underline{\hspace{2cm}}$

$$K_1 = 1.5752 \times 10^{-5} \frac{\mu_{\text{LFE}} T_m P_s^{0.7051} \mu_d}{P_{\text{LFE}} M_d^{0.2949} T_s^{0.07051}} = \underline{\hspace{2cm}}$$

$$K_2 = 0.1539 \frac{M_{\text{LFE}} T_m D_n^2 C_p \left[\frac{P_s}{T_s} \right]^{\frac{1}{2}}}{P_{\text{LFE}}}$$

$$K_4 = \frac{\mu_d}{M_w^{0.2051} M_d^{0.2949} (\mu_d - 74.143 B_{\text{ws}})} = \underline{\hspace{2cm}}$$

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$$A_2 = \frac{K_1}{X_r} - \frac{\mu_{LFE}}{180.1} \frac{Y_r}{X_r} = \text{_____}$$

$$B_2 = \frac{K_4 K_2}{X_r} = \text{_____}$$

Pressure head for recycle LFE:

$$\Delta P_r = A_2 - B_2 (\Delta p)^{\frac{1}{2}} = \text{_____ in. H}_2\text{O}$$

Figure 9. Example worksheet 3, recycle LFE pressure head.

| Run Code | Date | Stack Temperature (°F) | | Gas Composition | | Notes |
|------------------------------------|------|------------------------|----------|-------------------|------------------|-------|
| | | Start Time | End Time | % CO ₂ | % O ₂ | |
| Sampler ID | | | | | | |
| Filter ID | | | | | | |
| Sampler Orientation | | | | | | |
| Sampling Location | | | | | | |
| Nozzle Diameter-ID (in.) | | | | | | |
| Operator (s) | | | | | | |
| Dual Manometer Leveled and Zeroed? | | | | | | |
| Run Time | | | | | | |
| Port No. Trav. Pl. | | | | | | |
| ΔP Pilot | | | | | | |
| ΔH Sample | | | | | | |
| ΔP Total | | | | | | |
| DGM Volume | | | | | | |
| ΔP Recycle | | | | | | |
| P Inlet | | | | | | |
| T ₁ Stack | | | | | | |
| T ₂ Recycle | | | | | | |
| T ₃ Probe | | | | | | |
| T ₄ LFE | | | | | | |
| T ₅ DGM | | | | | | |

Figure 10. Example EGR Procedure data sheet.

Plant _____ Acetone blank volume, ml _____
 Date _____ Acetone wash volume, ml (2) _____ (3) _____
 Run no. _____ Acetone blank conc., mg/mg (Equation 5-4, Method 5) _____
 Filter no. _____
 Amount liquid lost during transport _____

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Acetone wash blank, mg (Equation 5-5, Method 5) _____

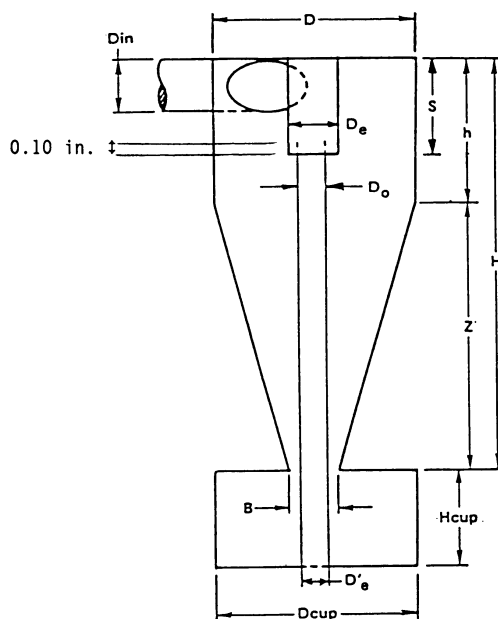
| Container number | Weight of particulate matter, mg | | |
|--------------------------|----------------------------------|-------------|-------------|
| | Final weight | Tare weight | Weight gain |
| 1 | | | |
| 3 | | | |
| Total | | | |
| Less acetone blank | | | |

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| Container number | Weight of particulate matter, mg | | |
|----------------------------------|----------------------------------|-------------|-------------|
| | Final weight | Tare weight | Weight gain |
| Weight of PM ₁₀ | | | |
| 2 | | | |
| Less acetone blank | | | |
| Total particulate weight | | | |

Figure 11. EGR method analysis sheet.

Cyclone Interior Dimensions



| Dimensions (± 0.02 cm, ± 0.01 in.) | | | | | | | | | | | | |
|---|----------|------|-------|------|------|------|------|------|-----------|-----------|--------|-------|
| | D_{in} | D | D_e | B | H | h | Z | S | H_{cup} | D_{cup} | D'_e | D_o |
| cm | 1.27 | 4.47 | 1.50 | 1.88 | 6.95 | 2.24 | 4.71 | 1.57 | 2.25 | 4.45 | 1.02 | 1.24 |
| inches | 0.50 | 1.76 | 0.59 | 0.74 | 2.74 | 0.88 | 1.85 | 0.62 | 0.89 | 1.75 | 0.40 | 0.49 |

Figure 12. Cyclone design specifications.

TABLE 1—PERFORMANCE SPECIFICATIONS FOR SOURCE PM_{10} CYCLONES AND NOZZLE COMBINATIONS

| Parameter | Units | Specification |
|---------------------------|---------------|---|
| 1. Collection efficiency. | Percent | Such that collection efficiency falls within envelope specified by Section 5.7.6 and Figure 13. |

TABLE 1—PERFORMANCE SPECIFICATIONS FOR SOURCE PM_{10} CYCLONES AND NOZZLE COMBINATIONS—Continued

| Parameter | Units | Specification |
|-----------------------------------|---------------|--|
| 2. Cyclone cut size (D_{50}). | μm | $10 \pm 1 \mu m$ aerodynamic diameter. |

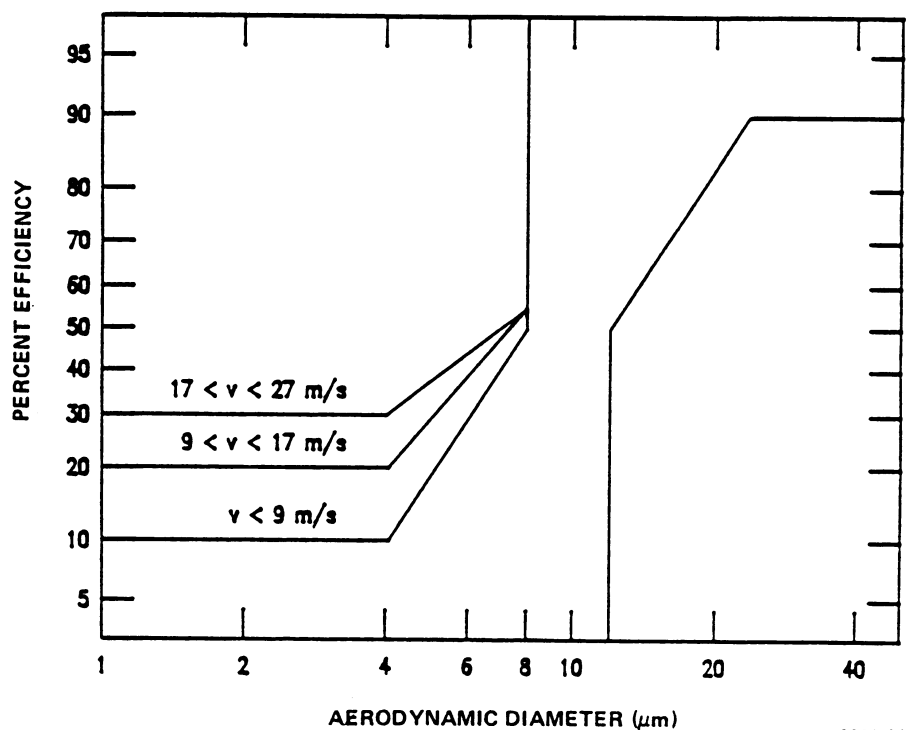
TABLE 2—PARTICLE SIZES AND NOMINAL GAS VELOCITIES FOR EFFICIENCY

| Particle size (μm) ^a | Target gas velocities (m/sec) | | |
|---|-------------------------------|--------------|--------------|
| | 7 \pm 1.0 | 15 \pm 1.5 | 25 \pm 2.5 |
| 5 \pm 0.5 | | | |
| 7 \pm 0.5 | | | |
| 10 \pm 0.5 | | | |

TABLE 2—PARTICLE SIZES AND NOMINAL GAS VELOCITIES FOR EFFICIENCY—Continued

| Particle size (μm) ^a | Target gas velocities (m/sec) | | |
|---|-------------------------------|--------------|--------------|
| | 7 \pm 1.0 | 15 \pm 1.5 | 25 \pm 2.5 |
| 14 \pm 1.0 | | | |
| 20 \pm 1.0 | | | |

(a) Mass median aerodynamic diameter.



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Figure 13. Efficiency envelope for the PM₁₀ cyclone.EMISSION GAS RECYCLE, DATA REDUCTION,
VERSION 3.4 MAY 1986

Test ID. Code: Chapel Hill 2.
 Test Location: Baghouse Outlet.
 Test Site: Chapel Hill.
 Test Date: 10/20/86.
 Operators(s): JB RH MH.

Entered Run Data

Temperatures:
 T(STK) 251.0 F
 T(RCL) 259.0 F
 T(LFE) 81.0 F
 T(DGM) 76.0 F

System Pressures:

DH(ORI) 1.18 INWG
 DP(TOT) 1.91 INWG
 P(INL) 12.15 INWG
 DP(RCL) 2.21 INWG
 DP(PTO) 0.06 INWG

Miscellanea:

P(BAR) 29.99 INWG
 DP(STK) 0.10 INWG
 V(DGM) 13.744 FT³
 TIME 60.00 MIN
 % CO₂ 8.00
 % O₂ 20.00
 NO₂ (IN) 0.2500

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| | | | |
|---------------------------|---------|------------------|--------|
| Water Content: | | DH@ (ORI) | 10.980 |
| Estimate | 0.0% | M(TOT LFE) | 0.2298 |
| or | | B(TOT LFE) | -.0058 |
| Condenser | 7.0 ML | M(RCL LFE) | 0.0948 |
| Column | 0.0 GM | B(RCL LFE) | -.0007 |
| Raw Masses: | | DGM GAMMA | 0.9940 |
| Cyclone 1 | 21.7 MG | | |
| Filter | 11.7 MG | | |
| Impinger Residue | 0.0 MG | | |
| Blank Values: | | | |
| CYC Rinse | 0.0 MG | | |
| Filter Holder Rinse | 0.0 MG | | |
| Filter Blank | 0.0 MG | | |
| Impinger Rinse | 0.0 MG | | |
| Calibration Values: | | | |
| CP(PITOT) | 0.840 | | |

Reduced Data

| | |
|--------------------------------|--------|
| Stack Velocity (FT/SEC) | 15.95 |
| Stack Gas Moisture (%) | 2.4 |
| Sample Flow Rate (ACFM) | 0.3104 |
| Total Flow Rate (ACFM) | 0.5819 |
| Recycle Flow Rate (ACFM) | 0.2760 |
| Percent Recycle | 46.7 |
| Isokinetic Ratio (%) | 95.1 |

| | (Particulate) | | (MG/DNCM) | (GR/ACF) | (GR/DCF) | (LB/DSCF) (X 1E6) |
|-------------------------|---------------|-------|-----------|----------|----------|----------------------|
| | (UM) | (% <) | | | | |
| Cyclone 1 | 10.15 | 35.8 | 56.6 | 0.01794 | 0.02470 | 3.53701 |
| Backup Filter | | | 30.5 | 0.00968 | 0.01332 | 1.907 |
| Particulate Total | | | 87.2 | 0.02762 | 0.03802 | 5.444 |

Note: Figure 14. Example inputs and outputs of the EGR reduction program.

METHOD 201A—DETERMINATION OF PM₁₀ EMISSIONS (CONSTANT SAMPLING RATE PROCEDURE)

1. Applicability and Principle

1.1 Applicability. This method applies to the in-stack measurement of particulate matter (PM) emissions equal to or less than an aerodynamic diameter of nominally 10 (PM₁₀) from stationary sources. The EPA recognizes that condensible emissions not collected by an in-stack method are also PM₁₀, and that emissions that contribute to ambient, PM₁₀ levels are the sum of condensible emissions and emissions measured by an in-stack PM₁₀ method, such as this method or Method 201. Therefore, for establishing source contributions to ambient levels of PM₁₀, such as for emission inventory purposes, EPA suggests that source PM₁₀ measurement include both in-stack PM₁₀ and condensible emissions. Condensible emissions may be measured by an impinger analysis in combination with this method.

1.2 Principle. A gas sample is extracted at a constant flow rate through an in-stack sizing device, which separates PM greater than PM₁₀. Variations from isokinetic sampling conditions are maintained within well-defined limits. The particulate mass is determined gravimetrically after removal of uncombined water.

2. Apparatus

NOTE: Methods cited in this method are part of 40 CFR part 60, appendix A.

2.1 Sampling Train. A schematic of the Method 201A sampling train is shown in Figure 1 of this method. With the exception of the PM₁₀ sizing device and in-stack filter,

this train is the same as an EPA Method 17 train.

2.1.1 Nozzle. Stainless steel (316 or equivalent) with a sharp tapered leading edge. Eleven nozzles that meet the design specification in Figure 2 of this method are recommended. A larger number of nozzles with small nozzle increments increase the likelihood that a single nozzle can be used for the entire traverse. If the nozzles do not meet the design specifications in Figure 2 of this method, then the nozzles must meet the criteria in Section 5.2 of this method.

2.1.2 PM₁₀ Sizer. Stainless steel (316 or equivalent), capable of determining the PM₁₀ fraction. The sizing device shall be either a cyclone that meets the specifications in Section 5.2 of this method or a cascade impactor that has been calibrated using the procedure in Section 5.4 of this method.

2.1.3 Filter Holder. 63-mm, stainless steel. An Andersen filter, part number SE274, has been found to be acceptable for the in-stack filter. NOTE: Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

2.1.4 Pitot Tube. Same as in Method 5, Section 2.1.3. The pitot lines shall be made of heat resistant tubing and attached to the probe with stainless steel fittings.

2.1.5 Probe Liner. Optional, same as in Method 5, Section 2.1.2.

2.1.6 Differential Pressure Gauge, Condenser, Metering System, Barometer, and Gas Density Determination Equipment. Same as in Method 5, Sections 2.1.4, and 2.1.7 through 2.1.10, respectively.

2.2 Sample Recovery.

2.2.1 Nozzle, Sizing Device, Probe, and Filter Holder Brushes. Nylon bristle brushes with stainless steel wire shafts and handles, properly sized and shaped for cleaning the nozzle, sizing device, probe or probe liner, and filter holders.

2.2.2 Wash Bottles, Glass Sample Storage Containers, Petri Dishes, Graduated Cylinder and Balance, Plastic Storage Containers, Funnel and Rubber Policeman, and Funnel. Same as in Method 5, Sections 2.2.2 through 2.2.8, respectively.

2.3 Analysis. Same as in Method 5, Section 2.3.

3. Reagents

The reagents for sampling, sample recovery, and analysis are the same as that specified in Method 5, Sections 3.1, 3.2, and 3.3, respectively.

4. Procedure

4.1 Sampling. The complexity of this method is such that, in order to obtain reliable results, testers should be trained and experienced with the test procedures.

4.1.1 Pretest Preparation. Same as in Method 5, Section 4.1.1.

4.1.2 Preliminary Determinations. Same as in Method 5, Section 4.1.2, except use the directions on nozzle size selection and sampling time in this method. Use of any nozzle greater than 0.16 in. in diameter requires a sampling port diameter of 6 inches. Also, the required maximum number of traverse points at any location shall be 12.

4.1.2.1 The sizing device must be in-stack or maintained at stack temperature during sampling. The blockage effect of the CSR sampling assembly will be minimal if the cross-sectional area of the sampling assembly is 3 percent or less of the cross-sectional area of the duct. If the cross-sectional area of the assembly is greater than 3 percent of the cross-sectional area of the duct, then either determine the pitot coefficient at sampling conditions or use a standard pitot with a known coefficient in a configuration with the CSR sampling assembly such that flow disturbances are minimized.

4.1.2.2 The setup calculations can be performed by using the following procedures.

4.1.2.2.1 In order to maintain a cut size of 10 μm in the sizing device, the flow rate through the sizing device must be maintained at a constant, discrete value during the run. If the sizing device is a cyclone that meets the design specifications in Figure 3 of this method, use the equations in Figure 4 of this method to calculate three orifice heads (ΔH): one at the average stack temperature, and the other two at temperatures $\pm 28^\circ\text{C}$ ($\pm 50^\circ\text{F}$) of the average stack temperature. Use ΔH calculated at the average stack temperature as the pressure head for the sample flow rate as long as the stack temperature during the

run is within 28°C (50°F) of the average stack temperature. If the stack temperature varies by more than 28°C (50°F), then use the appropriate ΔH .

4.1.2.2.2 If the sizing device is a cyclone that does not meet the design specifications in Figure 3 of this method, use the equations in Figure 4 of this method, except use the procedures in Section 5.3 of this method to determine Q_c , the correct cyclone flow rate for a 10 μm size.

4.1.2.2.3 To select a nozzle, use the equations in Figure 5 of this method to calculate Δp_{\min} and Δp_{\max} for each nozzle at all three temperatures. If the sizing device is a cyclone that does not meet the design specifications in Figure 3 of this method, the example worksheets can be used.

4.1.2.2.4 Correct the Method 2 pitot readings to Method 201A pitot readings by multiplying the Method 2 pitot readings by the square of a ratio of the Method 201A pitot coefficient to the Method 2 pitot coefficient. Select the nozzle for which Δp_{\min} and Δp_{\max} bracket all of the corrected Method 2 pitot readings. If more than one nozzle meets this requirement, select the nozzle giving the greatest symmetry. Note that if the expected pitot reading for one or more points is near a limit for a chosen nozzle, it may be outside the limits at the time of the run.

4.1.2.2.5 Vary the dwell time, or sampling time, at each traverse point proportionately with the point velocity. Use the equations in Figure 6 of this method to calculate the dwell time at the first point and at each subsequent point. It is recommended that the number of minutes sampled at each point be rounded to the nearest 15 seconds.

4.1.3 Preparation of Collection Train. Same as in Method 5, Section 4.1.3, except omit directions about a glass cyclone.

4.1.4 Leak-Check Procedure. The sizing device is removed before the post-test leak-check to prevent any disturbance of the collected sample prior to analysis.

4.1.4.1 Pretest Leak-Check. A pretest leak-check of the entire sampling train, including the sizing device, is required. Use the leak-check procedure in Method 5, Section 4.1.4.1 to conduct a pretest leak-check.

4.1.4.2 Leak-Checks During Sample Run. Same as in Method 5, Section 4.1.4.1.

4.1.4.3 Post-Test Leak-Check. A leak-check is required at the conclusion of each sampling run. Remove the cyclone before the leak-check to prevent the vacuum created by the cooling of the probe from disturbing the collected sample and use the procedure in Method 5, Section 4.1.4.3 to conduct a post-test leak-check.

4.1.5 Method 201A Train Operation. Same as in Method 5, Section 4.1.5, except use the procedures in this section for isokinetic sampling and flow rate adjustment. Maintain the flow rate calculated in Section 4.1.2.2.1 of this method throughout the run provided the

stack temperature is within 28 °C (50 °F) of the temperature used to calculate ΔH . If stack temperatures vary by more than 28 °C (50 °F), use the appropriate ΔH value calculated in Section 4.1.2.2.1 of this method. Calculate the dwell time at each traverse point as in Figure 6 of this method.

4.2 Sample Recovery. If a cascade impactor is used, use the manufacturer's recommended procedures for sample recovery. If a cyclone is used, use the same sample recovery as that in Method 5, Section 4.2, except an increased number of sample recovery containers is required.

4.2.1 Container Number 1 (In-Stack Filter). The recovery shall be the same as that for Container Number 1 in Method 5, Section 4.2.

4.2.3 Container Number 2 (Cyclone or Large PM Catch). This step is optional. The anisokinetic error for the cyclone PM is theoretically larger than the error for the PM₁₀ catch. Therefore, adding all the fractions to get a total PM catch is not as accurate as Method 5 or Method 201. Disassemble the cyclone and remove the nozzle to recover the large PM catch. Quantitatively recover the PM from the interior surfaces of the nozzle and cyclone, excluding the "turn around" cup and the interior surfaces of the exit tube. The recovery shall be the same as that for Container Number 2 in Method 5, Section 4.2.

4.2.4 Container Number 3 (PM₁₀). Quantitatively recover the PM from all of the surfaces from the cyclone exit to the front half of the in-stack filter holder, including the "turn around" cup inside the cyclone and the interior surfaces of the exit tube. The recovery shall be the same as that for Container Number 2 in Method 5, Section 4.2.

4.2.6 Container Number 4 (Silica Gel). The recovery shall be the same as that for Container Number 3 in Method 5, Section 4.2.

4.2.7 Impinger Water. Same as in Method 5, Section 4.2, under "Impinger Water."

4.3 Analysis. Same as in Method 5, Section 4.3, except handle Method 201A Container Number 1 like Container Number 1, Method 201A Container Numbers 2 and 3 like Container Number 2, and Method 201A Container Number 4 like Container Number 3. Use Figure 7 of this method to record the weights of PM collected. Use Figure 5-3 in Method 5, Section 4.3, to record the volume of water collected.

4.4 Quality Control Procedures. Same as in Method 5, Section 4.4.

4.5 PM₁₀ Emission Calculation and Acceptability of Results. Use the procedures in section 6 to calculate PM₁₀ emissions and the criteria in section 6.3.5 to determine the acceptability of the results.

5. Calibration

Maintain an accurate laboratory log of all calibrations.

5.1 Probe Nozzle, Pitot Tube, Metering System, Probe Heater Calibration, Temperature Gauges, Leak-check of Metering System, and Barometer. Same as in Method 5, Section 5.1 through 5.7, respectively.

5.2 Probe Cyclone and Nozzle Combinations. The probe cyclone and nozzle combinations need not be calibrated if both meet design specifications in Figures 2 and 3 of this method. If the nozzles do not meet design specifications, then test the cyclone and nozzle combinations for conformity with performance specifications (PS's) in Table 1 of this method. If the cyclone does not meet design specifications, then the cyclone and nozzle combination shall conform to the PS's and calibrate the cyclone to determine the relationship between flow rate, gas viscosity, and gas density. Use the procedures in Section 5.2 of this method to conduct PS tests and the procedures in Section 5.3 of this method to calibrate the cyclone. The purpose of the PS tests are to conform that the cyclone and nozzle combination has the desired sharpness of cut. Conduct the PS tests in a wind tunnel described in Section 5.2.1 of this method and particle generation system described in Section 5.2.2 of this method. Use five particle sizes and three wind velocities as listed in Table 2 of this method. A minimum of three replicate measurements of collection efficiency shall be performed for each of the 15 conditions listed, for a minimum of 45 measurements.

5.2.1 Wind Tunnel. Perform the calibration and PS tests in a wind tunnel (or equivalent test apparatus) capable of establishing and maintaining the required gas stream velocities within 10 percent.

5.2.2 Particle Generation System. The particle generation system shall be capable of producing solid monodispersed dye particles with the mass median aerodynamic diameters specified in Table 2 of this method. Perform the particle size distribution verification on an integrated sample obtained during the sampling period of each test. An acceptable alternative is to verify the size distribution of samples obtained before and after each test, with both samples required to meet the diameter and monodispersity requirements for an acceptable test run.

5.2.2.1 Establish the size of the solid dye particles delivered to the test section of the wind tunnel by using the operating parameters of the particle generation system, and verify them during the tests by microscopic examination of samples of the particles collected on a membrane filter. The particle size, as established by the operating parameters of the generation system, shall be within the tolerance specified in Table 2 of this method. The precision of the particle size verification technique shall be at least ± 0.5 μm , and particle size determined by the verification technique shall not differ by

more than 10 percent from that established by the operating parameters of the particle generation system.

5.2.2.2 Certify the monodispersity of the particles for each test either by microscopic inspection of collected particles on filters or by other suitable monitoring techniques such as an optical particle counter followed by a multichannel pulse height analyzer. If the proportion of multiplets and satellites in an aerosol exceeds 10 percent by mass, the particle generation system is unacceptable for the purpose of this test. Multiplets are particles that are agglomerated, and satellites are particles that are smaller than the specified size range.

5.2.3 Schematic Drawings. Schematic drawings of the wind tunnel and blower system and other information showing complete procedural details of the test atmosphere generation, verification, and delivery techniques shall be furnished with calibration data to the reviewing agency.

5.2.4 Flow Measurements. Measure the cyclone air flow rates with a dry gas meter and a stopwatch, or a calibrated orifice system capable of measuring flow rates to within 2 percent.

5.2.5 Performance Specification Procedure. Establish test particle generator operation and verify particle size microscopically. If

monodispersity is to be verified by measurements at the beginning and the end of the run rather than by an integrated sample, these measurements may be made at this time.

5.2.5.1 The cyclone cut size, or D_{50} , of a cyclone is defined here as the particle size having a 50 percent probability of penetration. Determine the cyclone flow rate at which D_{50} is 10 μm . A suggested procedure is to vary the cyclone flow rate while keeping a constant particle size of 10 μm . Measure the PM collected in the cyclone (m_c), the exit tube (m_t), and the filter (m_f). Calculate cyclone efficiency (E_c) for each flow rate as follows:

$$E_c = \frac{m_c}{(m_c + m_t + m_f)} \times 100$$

5.2.5.2. Do three replicates and calculate the average cyclone efficiency [$E_{c(\text{avg})}$] as follows:

$$E_{c(\text{avg})} = (E_1 + E_2 + E_3) / 3$$

Where E_1 , E_2 , and E_3 are replicate measurements of E_c .

5.2.5.3 Calculate the standard deviation (σ) for the replicate measurements of E_c as follows:

$$\sigma = \left[\frac{(E_1^2 + E_2^2 + E_3^2) - \frac{(E_1 + E_2 + E_3)^2}{3}}{2} \right]^{\frac{1}{2}}$$

If σ exceeds 0.10, repeat the replicated runs.

5.2.5.4 Measure the overall efficiency of the cyclone and nozzle, E_o , at the particle sizes and nominal gas velocities in Table 2 of this method using the following procedure.

5.2.5.5 Set the air velocity and particle size from one of the conditions in Table 2 of this method. Establish isokinetic sampling conditions and the correct flow rate in the cyclone (obtained by procedures in this section) such that the D_{50} is 10 μm . Sample long enough to obtain ± 5 percent precision on total collected mass as determined by the precision and the sensitivity of measuring technique. Determine separately the nozzle catch (m_n), cyclone catch (m_c), cyclone exit tube (M_t), and collection filter catch (m_f) for each particle size and nominal gas velocity in Table 2 of this method. Calculate overall efficiency (E_o) as follows:

$$E_o = \frac{(m_n + m_c)}{(m_n + m_c + m_t + m_f)} \times 100$$

5.2.5.6 Do three replicates for each combination of gas velocity and particle size in Table 2 of this method. Use the equation below to calculate the average overall efficiency [$E_{o(\text{avg})}$] for each combination following the procedures described in this section for determining efficiency.

$$E_{o(\text{avg})} = (E_1 + E_2 + E_3) / 3$$

Where E_1 , E_2 , and E_3 are replicate measurements of E_o .

5.2.5.7 Use the formula in Section 5.2.5.3 to calculate σ for the replicate measurements. If σ exceeds 0.10 or if the particle sizes and nominal gas velocities are not within the

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limits specified in Table 2 of this method, repeat the replicate runs.

5.2.6 Criteria for Acceptance. For each of the three gas stream velocities, plot the $E_{o(avg)}$ as a function of particle size on Figure 8 of this method. Draw smooth curves through all particle sizes. $E_{o(avg)}$ shall be within the banded region for all sizes, and the $E_{c(avg)}$ shall be 50 ± 0.5 percent at $10 \mu m$.

5.3 Cyclone Calibration Procedure. The purpose of this procedure is to develop the relationship between flow rate, gas viscosity, gas density, and D_{50} .

5.3.1 Calculate Cyclone Flow Rate. Determine flow rates and D_{50} 's for three different particle sizes between $5 \mu m$ and $15 \mu m$, one of which shall be $10 \mu m$. All sizes must be determined within $0.5 \mu m$. For each size, use a different temperature within $60^\circ C$ ($108^\circ F$) of the temperature at which the cyclone is to be used and conduct triplicate runs. A suggested procedure is to keep the particle size constant and vary the flow rate.

5.3.1.1 On log-log graph paper, plot the Reynolds number (Re) on the abscissa, and the square root of the Stokes 50 number $[(Stk_{50})^{1/2}]$ on the ordinate for each tempera-

ture. Use the following equations to compute both values:

$$Re = \frac{4 \rho Q_{cyc}}{d_{cyc} \pi \mu_s}$$

$$(Stk_{50})^{1/2} = \left[\frac{4 Q_{cyc} (D_{50})^2}{(9 \pi \mu_s)^3 (d_{cyc})^3} \right]^{1/2}$$

where:

Q_{cyc} = Cyclone flow rate, cm^3/sec .

ρ = Gas density, g/cm^3 .

d_{cyc} = Diameter of cyclone inlet, cm .

μ_s = Viscosity of stack gas, micropoise.

D_{50} = Aerodynamic diameter of a particle having a 50 percent probability of penetration, cm .

5.3.1.2 Use a linear regression analysis to determine the slope (m) and the Y-intercept (b). Use the following formula to determine Q , the cyclone flow rate required for a cut size of $10 \mu m$.

$$Q_s = \frac{\pi \mu_s}{4} [(3000)(K_1) - b]^{-(0.5-m)} \left[\frac{T_s}{M_w P_s} \right]^{m/(m-0.5)} d^{(m-1.5)/(m-0.5)}$$

where:

m = Slope of the calibration line.

b = y-intercept of the calibration line.

Q_s = Cyclone flow rate for a cut size of $10 \mu m$, cm^3/sec .

d = Diameter of nozzle, cm .

T_s = Stack gas temperature, $^\circ R$.

P_s = Absolute stack pressure, $in. Hg$.

M_w = Wet molecular weight of the stack gas, $lb/lb-mole$.

$K_1 = 4.077 \times 10^{-3}$.

5.3.1.3 Refer to the Method 201A operators manual, entitled *Application Guide for Source PM_{10} Measurement with Constant Sampling Rate*, for directions in the use of this equation for Q in the setup calculations.

5.4 Cascade Impactor. The purpose of calibrating a cascade impactor is to determine the empirical constant (STK_{50}), which is specific to the impactor and which permits the accurate determination of the cut size of the impactor stages at field conditions. It is not necessary to calibrate each individual impactor. Once an impactor has been calibrated, the calibration data can be applied to other impactors of identical design.

5.4.1 Wind Tunnel. Same as in Section 5.2.1 of this method.

5.4.2 Particle Generation System. Same as in Section 5.2.2 of this method.

5.4.3 Hardware Configuration for Calibrations. An impaction stage constrains an aerosol to form circular or rectangular jets, which are directed toward a suitable substrate where the larger aerosol particles are collected. For calibration purposes, three stages of the cascade impactor shall be discussed and designated calibration stages 1, 2, and 3. The first calibration stage consists of the collection substrate of an impaction stage and all upstream surfaces up to and including the nozzle. This may include other preceding impactor stages. The second and third calibration stages consist of each respective collection substrate and all upstream surfaces up to but excluding the collection substrate of the preceding calibration stage. This may include intervening impactor stages which are not designated as calibration stages. The cut size, or D_{50} , of the adjacent calibration stages shall differ by a factor of not less than 1.5 and not more than 2.0. For example, if the first calibration stage has a D_{50} of $12 \mu m$, then the D_{50} of the downstream stage shall be between 6 and $8 \mu m$.

5.4.3.1 It is expected, but not necessary, that the complete hardware assembly will be used in each of the sampling runs of the calibration and performance determinations.

Only the first calibration stage must be tested under isokinetic sampling conditions. The second and third calibration stages must be calibrated with the collection substrate of the preceding calibration stage in place, so that gas flow patterns existing in field operation will be simulated.

5.4.3.2 Each of the PM₁₀ stages should be calibrated with the type of collection substrate, viscous material (such as grease) or glass fiber, used in PM₁₀ measurements. Note that most materials used as substrates at elevated temperatures are not viscous at normal laboratory conditions. The substrate material used for calibrations should minimize particle bounce, yet be viscous enough to withstand erosion or deformation by the impactor jets and not interfere with the procedure for measuring the collected PM.

5.4.4 Calibration Procedure. Establish test particle generator operation and verify particle size microscopically. If monodispersity is to be verified by measurements at the beginning and the end of the run rather than by an integrated sample, these measurements shall be made at this time. Measure in triplicate the PM collected by the calibration stage (m) and the PM on all surfaces downstream of the respective calibration stage (m') for all of the flow rates and particle size combinations shown in Table 2 of this method. Techniques of mass measurement may include the use of a dye and spectrophotometer. Particles on the upstream side of a jet plate shall be included with the substrate downstream, except agglomerates of particles, which shall be included with the preceding or upstream substrate. Use the following formula to calculate the collection efficiency (E) for each stage.

5.4.4.1 Use the formula in Section 5.2.5.3 of this method to calculate the standard deviation (σ) for the replicate measurements. If σ exceeds 0.10, repeat the replicate runs.

5.4.4.2 Use the following formula to calculate the average collection efficiency (E_{avg}) for each set of replicate measurements.

$$E_{avg} = (E_1 + E_2 + E_3) / 3$$

where E_1 , E_2 , and E_3 are replicate measurements of E.

5.4.4.3 Use the following formula to calculate Stk for each E_{avg} .

$$Stk = \frac{D^2 Q}{9 \mu A d_j}$$

where:

D = Aerodynamic diameter of the test particle, cm (g/cm^3)^{1/2}.

Q = Gas flow rate through the calibration stage at inlet conditions, cm³/sec.

μ = Gas viscosity, micropoise.

A = Total cross-sectional area of the jets of the calibration stage, cm².

d_j = Diameter of one jet of the calibration stage, cm.

5.4.4.4 Determine Stk₅₀ for each calibration stage by plotting E_{avg} versus Stk on log-log paper. Stk₅₀ is the Stk number at 50 percent efficiency. Note that particle bounce can cause efficiency to decrease at high values of Stk. Thus, 50 percent efficiency can occur at multiple values of Stk. The calibration data should clearly indicate the value of Stk₅₀ for minimum particle bounce. Impactor efficiency versus Stk with minimal particle bounce is characterized by a monotonically increasing function with constant or increasing slope with increasing Stk.

5.4.4.5 The Stk₅₀ of the first calibration stage can potentially decrease with decreasing nozzle size. Therefore, calibrations should be performed with enough nozzle sizes to provide a measured value within 25 percent of any nozzle size used in PM₁₀ measurements.

5.4.5 Criteria For Acceptance. Plot E_{avg} for the first calibration stage versus the square root of the ratio of Stk to Stk₅₀ on Figure 9 of this method. Draw a smooth curve through all of the points. The curve shall be within the banded region.

6. Calculations

Calculations are as specified in Method 5, sections 6.3 through 6.7, and 6.9 through 6.11, with the addition of the following:

6.1 Nomenclature.

B_{ws} = Moisture fraction of stack, by volume, dimensionless.

C_1 = Viscosity constant, 51.12 micropoise for °K (51.05 micropoise for °R).

C_2 = Viscosity constant, 0.372 micropoise/°K (0.207 micropoise/°R).

C_3 = Viscosity constant, 1.05×10^{-4} micropoise/°K² (3.24×10^{-5} micropoise/°R²).

C_4 = Viscosity constant, 53.147 micropoise/fraction O₂.

C_5 = Viscosity constant, 74.143 micropoise/fraction H₂O.

D_{50} = Diameter of particles having a 50 percent probability of penetration, μ m.

f_o = Stack gas fraction O₂, by volume, dry basis.

K_1 = 0.3858 °K/mm Hg (17.64 °R/in. Hg).

M_w = Wet molecular weight of stack gas, g/g-mole (lb/lb-mole).

M_d = Dry molecular weight of stack gas, g/g-mole (lb/lb-mole).

P_{bar} = Barometric pressure at sampling site, mm Hg (in. Hg).

P_s = Absolute stack pressure, mm Hg (in. Hg).

Q_s = Total cyclone flow rate at wet cyclone conditions, m³/min (ft³/min).

$Q_{s(std)}$ = Total cyclone flow rate at standard conditions, dscm/min (dscf/min).

T_m = Average absolute temperature of dry meter, °K (°R).

T_s = Average absolute stack gas temperature, °K (°R).

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$V_{w(std)}$ =Volume of water vapor in gas sample (standard conditions), scm (scf).

θ =Total sampling time, min.

μ_s =Viscosity of stack gas, micropoise.

6.2 Analysis of Cascade Impactor Data. Use the manufacturer's recommended procedures to analyze data from cascade impactors.

6.3 Analysis of Cyclone Data. Use the following procedures to analyze data from a single stage cyclone.

6.3.1 PM_{10} Weight. Determine the PM catch in the PM_{10} range from the sum of the weights obtained from Container Numbers 1 and 3 less the acetone blank.

6.3.2 Total PM Weight (optional). Determine the PM catch for greater than PM_{10} from the weight obtained from Container Number 2 less the acetone blank, and add it to the PM_{10} weight.

6.3.3 PM_{10} Fraction. Determine the PM_{10} fraction of the total particulate weight by dividing the PM_{10} particulate weight by the total particulate weight.

6.3.4 Aerodynamic Cut Size. Calculate the stack gas viscosity as follows:

$$\mu_s = C_1 + C_2 T_s + C_3 T_s^2 + C_4 f_{02} - C_5 B_{ws}$$

6.3.4.1 The PM_{10} flow rate, at actual cyclone conditions, is calculated as follows:

$$Q_s = \frac{T_s}{K_1 P_s} \left[Q_{s(std)} + \frac{V_{w(std)}}{\theta} \right]$$

6.3.4.2 Calculate the molecular weight on a wet basis of the stack gas as follows:

$$M_w = M_d (1 - B_{ws}) + 18.0 (B_{ws})$$

6.3.4.3 Calculate the actual D_{50} of the cyclone for the given conditions as follows:

$$D_{50} = \beta_1 \left[\frac{T_s}{M_w P_s} \right]^{0.2091} \left[\frac{\mu_s}{Q_s} \right]^{0.7091}$$

where $\beta_1 = 0.027754$ for metric units (0.15625 for English units).

6.3.5 Acceptable Results. The results are acceptable if two conditions are met. The first is that $9.0 \mu m \leq D_{50} \leq 11.0 \mu m$. The second is that no sampling points are outside Δp_{min} and Δp_{max} , or that 80 percent $\leq I \leq 120$ percent and no more than one sampling point is outside Δp_{min} and Δp_{max} . If D_{50} is less than $9.0 \mu m$, reject the results and repeat the test.

7. Bibliography

1. Same as Bibliography in Method 5.
2. McCain, J.D., J.W. Ragland, and A.D. Williamson. Recommended Methodology for the Determination of Particle Size Distributions in Ducted Sources, Final Report. Prepared for the California Air Resources Board by Southern Research Institute. May 1986.
3. Farthing, W.E., S.S. Dawes, A.D. Williamson, J.D. McCain, R.S. Martin, and J.W. Ragland. Development of Sampling Methods for Source PM_{10} Emissions. Southern Research Institute for the Environmental Protection Agency. April 1989. NTIS PB 89 190375, EPA/600/3-88-056.
4. Application Guide for Source PM_{10} Measurement with Constant Sampling Rate, EPA/600/3-88-057.

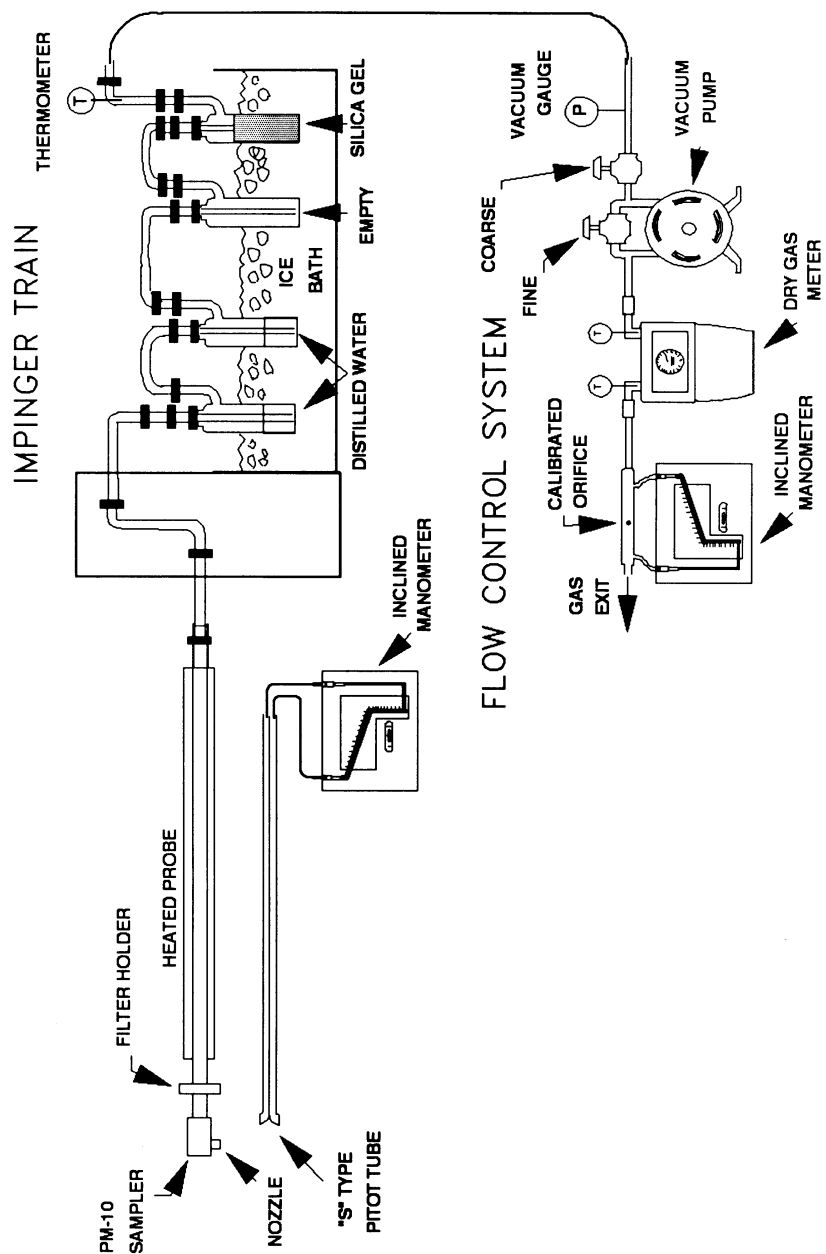
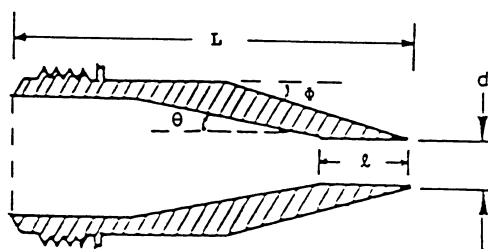


Figure 1. CSR Sampling Train



| Nozzle Diameter (inches) | Cone Angle, θ (degrees) | Outside taper, ϕ (degrees) | Straight inlet length, l (inches) | Total Length L (inches) |
|-----------------------------|-----------------------------------|------------------------------------|--|---------------------------------|
| 0.136 | 4 | 15 | <0.05 | 2.653 ± 0.05 |
| 0.150 | 4 | 15 | <0.05 | 2.553 ± 0.05 |
| 0.164 | 5 | 15 | <0.05 | 1.970 ± 0.05 |
| 0.180 | 6 | 15 | <0.05 | 1.572 ± 0.05 |
| 0.197 | 6 | 15 | <0.05 | 1.491 ± 0.05 |
| 0.215 | 6 | 15 | <0.05 | 1.45 ± 0.05 |
| 0.233 | 6 | 15 | <0.05 | 1.45 ± 0.05 |
| 0.264 | 5 | 15 | <0.05 | 1.45 ± 0.05 |
| 0.300 | 4 | 15 | <0.05 | 1.48 ± 0.05 |
| 0.342 | 4 | 15 | <0.05 | 1.45 ± 0.05 |
| 0.390 | 3 | 15 | <0.05 | 1.45 ± 0.05 |

Figure 2. Nozzle design specifications.

Cyclone Interior Dimensions

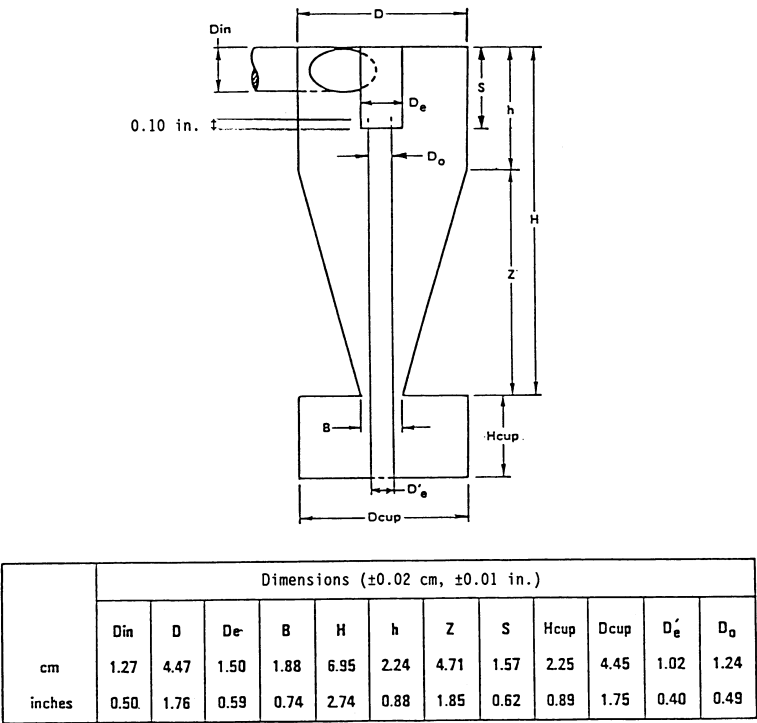


Figure 3. Cyclone design specifications.

Barometric pressure,
 P_{bar} , in. Hg= _____
Stack static pressure,
 P_g , in. H₂ O= _____
Average stack temperature,
 t_s , °F= _____
Meter temperature, t_m , °F= _____
Orifice ΔH_2 , in. H₂ O= _____
Gas analysis:
%CO₂= _____
%O₂= _____
%N₂+%CO= _____
Fraction moisture content,
 B_{ws} = _____

Molecular weight of stack gas, dry basis:
 $M_d=0.44$ (%CO₂)+0.32 (%O₂)+0.28 (%N₂+%CO)= _____ lb/lb mole
Molecular weight of stack gas, wet basis:
 $M_w=M_d(1-B_{ws})+18(B_{ws})=$ _____ lb/lb mole
Absolute stack pressure:

$$P_s = P_{bar} + \frac{P_g}{13.6} = \text{_____ in. Hg}$$

Viscosity of stack gas:
 $\mu_s=152.418+0.2552 t_s+3.2355 \times 10^{-5} t_s^2+0.53147$
(%O₂)-74.143 B_{ws} = _____ micropoise
Cyclone flow rate:

$$Q_s = 0.002837 \mu_s \left[\frac{(t_s + 460)}{M_w P_s} \right]^{0.2949} = \text{____ ft}^3/\text{min}$$

Figure 4. Example worksheet 1, cyclone Orifice pressure head (ΔH) needed for cyclone flow rate and ΔH .

$$\Delta H = \left[\frac{Q_s (1 - B_{ws}) P_s}{t_s + 460} \right]^2 \frac{t_{m+460} M_d 1.083 \Delta H_{@}}{P_{bar}} = \text{____ in. H}_2\text{O}$$

Calculate ΔH for three temperatures:

| | | | |
|-----------------------------------|--|--|--|
| t_s , °F | | | |
| ΔH , in. H ₂ O | | | |

Stack viscosity, μ_s ,

micropoise = ____

Absolute stack pressure,

P_s , in. Hg = ____

Average stack temperature,

t_s , °F = ____

Meter temperature, t_m , °F = ____

Method 201A pitot coefficient,

C_p = ____

Cyclone flow rate, ft³/min,

Q_s = ____

Method 2 pitot coefficient,

C_p' = ____

Molecular weight of stack gas, wet basis,

M_w = ____

Nozzle diameter, D_n , in. = ____

Nozzle velocity:

$$v_n = \frac{3.056 Q_s}{D_n^2} = \text{____ ft/sec}$$

$$v_{\min} = v_n \left[0.2457 + \left[0.3072 - \frac{0.2603 Q_s^{\frac{1}{2}} \mu_s}{v_n^{1.5}} \right]^{\frac{1}{2}} \right] = \text{____ ft/sec}$$

$$v_{\max} = v_n \left[0.4457 + \left[0.5690 - \frac{0.2603 Q_s^{\frac{1}{2}} \mu_s}{v_n^{1.5}} \right]^{\frac{1}{2}} \right] = \text{____ ft/sec}$$

Maximum and minimum velocities:

Calculate R_{\min}

$$R_{\min} = 0.2457 + 0.3072 - \frac{0.2603 (\sqrt{Q_s}) \mu_s}{v_n^{1.5}} = \text{____}$$

If R_{\min} is less than 0.5, or if an imaginary number occurs when calculating R_{\min} , use

Equation 1 to calculate v_{\min} . Otherwise, use Equation 2.

Eq. 1 $v_{\min} = v_n (0.5) = \text{____ ft/sec}$

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Eq. 2 $v_{\min} = v_n R_{\min} = \underline{\hspace{1cm}}$ ft/sec
Calculate R_{\max} .

$$R_{\max} = 0.4457 + 0.5690 + \frac{0.2603(\sqrt{Q_s})\mu_s}{v_n 1.5} = \underline{\hspace{1cm}}$$

If R_{\max} is greater than 1.5, use Equation 3 to calculate v_{\max} . Otherwise, use Equation 4.

Eq. 3 $v_{\max} = v_n (1.5) = \underline{\hspace{1cm}}$ ft/sec

Eq. 4 $v_{\max} = v_n R_{\max} = \underline{\hspace{1cm}}$ ft/sec

Figure 5. Example worksheet 2, nozzle selection.

Maximum and minimum velocity head values:

$$\Delta p_{\min} = 1.3686 \times 10^{-4} \frac{P_s M_w (v_{\min})^2}{(t_s + 460) C_p^2} = \underline{\hspace{1cm}} \text{ in. H}_2\text{O}$$

$$\Delta p_{\max} = 1.3686 \times 10^{-4} \frac{P_s M_w (v_{\max})^2}{(t_s + 460) C_p^2} = \underline{\hspace{1cm}} \text{ in. H}_2\text{O}$$

| Nozzle No. | | | | |
|---------------------------|-------|-------|-------|-------|
| D_n , in. .... | ..... | ..... | ..... | ..... |
| v_n , ft/sec ..... | ..... | ..... | ..... | ..... |
| v_{\min} , ft/sec ..... | ..... | ..... | ..... | ..... |
| v_{\max} , ft/sec ..... | ..... | ..... | ..... | ..... |

| Nozzle No. | | | | |
|--|-------|-------|-------|-------|
| Δp_{\min} , in. H ₂ O ..... | ..... | ..... | ..... | ..... |
| Δp_{\max} , in. H ₂ O ..... | ..... | ..... | ..... | ..... |

Velocity traverse data:

$$\Delta p(\text{Method 201A}) = \Delta p(\text{Method 2}) \left[\frac{C_p}{C_{p'}} \right]^2$$

Total run time, minutes =
Number of traverse points =

$$t_1 = \left[\frac{\Delta p'_1}{\Delta p'_{\text{avg}}} \right]^{\frac{1}{2}} \frac{(\text{Total run time})}{(\text{Number of points})}$$

where:

t_1 = dwell time at first traverse point, minutes.

$\Delta p'_1$ = the velocity head at the first traverse point (from a previous traverse), in. H₂O.

$\Delta p'_{\text{avg}}$ = the square of the average square root of the Δp 's (from a previous velocity traverse), in. H₂O.

At subsequent traverse points, measure the velocity Δp and calculate the dwell time by using the following equation:

$$t_n = \frac{t_1}{(\Delta p_1)^{\frac{1}{2}}} (\Delta p_n)^{\frac{1}{2}}, \quad n = 2, 3, \dots, \text{total number of sampling points}$$

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where:

t_n = dwell time at traverse point n, minutes.

Δp_n = measured velocity head at point n, in. H_2O .

Δp_1 = measured velocity head at point 1 in. H_2O .

Figure 6. Example worksheet 3, dwell time.

| Point No. | Port | | | | | | | |
|-----------|------------|-------|------------|-------|------------|-------|------------|-------|
| | Δp | t | Δp | t | Δp | t | Δp | t |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |

Plant _____
 Date _____
 Run no. _____
 Filter no. _____
 Amount of liquid lost during transport _____
 Acetone blank volume, ml _____
 Acetone wash volume, ml (4) _____
 (5) _____
 Acetone blank conc., mg/mg (Equation 5-4, Method 5) _____
 Acetone wash blank, mg (Equation 5-5, Method 5) _____

TABLE 1—PERFORMANCE SPECIFICATIONS FOR SOURCE PM_{10} CYCLONES AND NOZZLE COMBINATIONS

| Parameter | Units | Specifications |
|-----------------------------------|---------------|--|
| 1. Collection efficiency. | Percent | Such that collection efficiency falls within envelope specified by Section 5.2.6 and Figure 8. |
| 2. Cyclone cut size (D_{50}). | μm | $10 \pm 1 \mu m$ aerodynamic diameter. |

TABLE 2—PARTICLE SIZES AND NOMINAL GAS VELOCITIES FOR EFFICIENCY

| Particle size (μm) ^a | Target gas velocities (m/sec) | | |
|--|-------------------------------|--------------|--------------|
| | 7 \pm 1.0 | 15 \pm 1.5 | 25 \pm 2.5 |
| 5 \pm 0.5 | | | |
| 7 \pm 0.5 | | | |
| 10 \pm 0.5 | | | |
| 14 \pm 1.0 | | | |
| 20 \pm 1.0 | | | |

(^a) Mass median aerodynamic diameter.

| Container No. | Weight of PM_{10} (mg) | | |
|---------------------------|--------------------------|-------------|-------------|
| | Final weight | Tare weight | Weight gain |
| 1 | | | |
| 3 | | | |
| Total | | | |
| Less acetone blank | | | |
| Weight of PM_{10} | | | |

Figure 7. Method 201A analysis sheet.

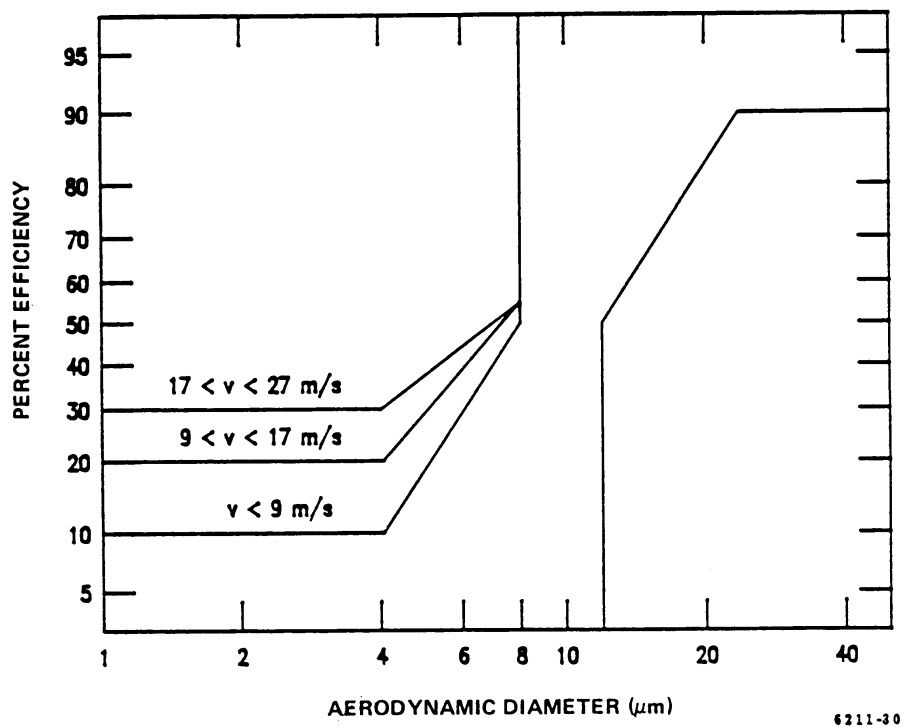
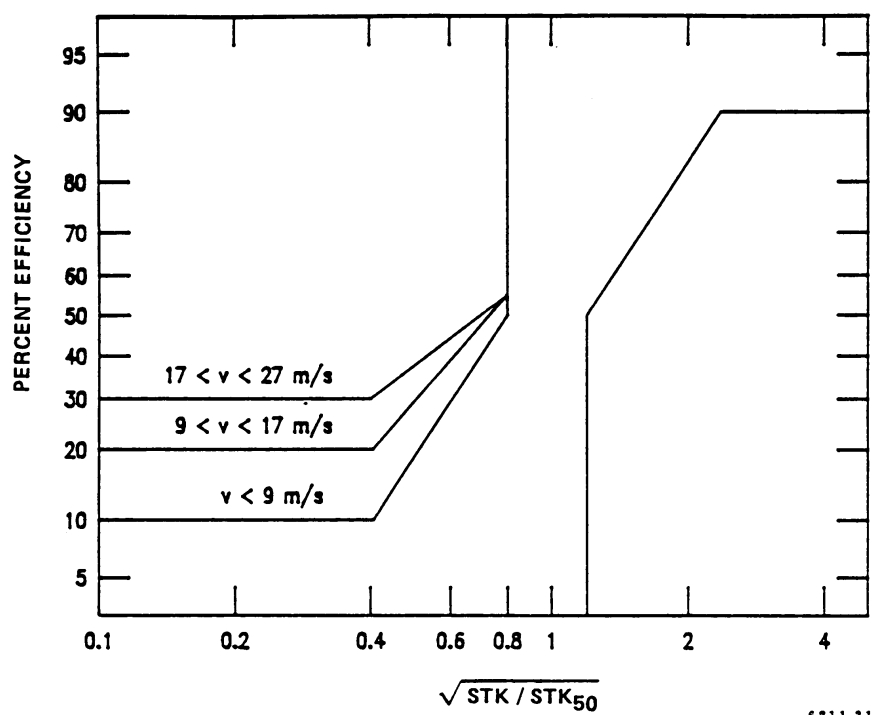


Figure 8. Efficiency envelope for the PM_{10} cyclone.



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Figure 9. Efficiency envelope for first calibration stage.

METHOD 202—DETERMINATION OF CONDENSIBLE PARTICULATE EMISSIONS FROM STATIONARY SOURCES

1. Applicability and Principle

1.1 Applicability.

1.1.1 This method applies to the determination of condensible particulate matter (CPM) emissions from stationary sources. It is intended to represent condensible matter as material that condenses after passing through a filter and as measured by this method (Note: The filter catch can be analyzed according to the appropriate method).

1.1.2 This method may be used in conjunction with Method 201 or 201A if the probes are glass-lined. Using Method 202 in conjunction with Method 201 or 201A, only the impinger train configuration and analysis is addressed by this method. The sample train operation and front end recovery and analysis shall be conducted according to Method 201 or 201A.

1.1.3 This method may also be modified to measure material that condenses at other

temperatures by specifying the filter and probe temperature. A heated Method 5 out-of-stack filter may be used instead of the in-stack filter to determine condensible emissions at wet sources.

1.2 Principle.

1.2.1 The CPM is collected in the impinger portion of a Method 17 (appendix A, 40 CFR part 60) type sampling train. The impinger contents are immediately purged after the run with nitrogen (N_2) to remove dissolved sulfur dioxide (SO_2) gases from the impinger contents. The impinger solution is then extracted with methylene chloride ($MeCl_2$). The organic and aqueous fractions are then taken to dryness and the residues weighed. The total of both fractions represents the CPM.

1.2.2 The potential for low collection efficiency exist at oil-fired boilers. To improve the collection efficiency at these type of sources, an additional filter placed between the second and third impinger is recommended.

2. Precision and Interference

2.1 Precision. The precision based on method development tests at an oil-fired boiler and a catalytic cracker were 11.7 and 4.8 percent, respectively.

2.2 Interference. Ammonia. In sources that use ammonia injection as a control technique for hydrogen chloride (HCl), the ammonia interferes by reacting with HCl in the gas stream to form ammonium chloride (NH₄Cl) which would be measured as CPM. The sample may be analyzed for chloride and the equivalent amount of NH₄Cl can be subtracted from the CPM weight. However, if NH₄Cl is to be counted as CPM, the inorganic fraction should be taken to near dryness (less than 1 ml liquid) in the oven and then allowed to air dry at ambient temperature to prevent any NH₄Cl from vaporizing.

3. Apparatus

3.1 Sampling Train. Same as in Method 17, section 2.1, with the following exceptions noted below (see Figure 202-1). *Note:* Mention of trade names or specific products does not constitute endorsement by EPA.

3.1.1 The probe extension shall be glass-lined or Teflon.

3.1.2 Both the first and second impingers shall be of the Greenburg-Smith design with the standard tip.

3.1.3 All sampling train glassware shall be cleaned prior to the test with soap and tap water, water, and rinsed using tap water, water, acetone, and finally, MeCl₂. It is important to completely remove all silicone grease from areas that will be exposed to the MeCl₂ during sample recovery.

3.2 Sample Recovery. Same as in Method 17, section 2.2, with the following additions:

3.2.1 N₂ Purge Line. Inert tubing and fittings capable of delivering 0 to 28 liters/min of N₂ gas to the impinger train from a standard gas cylinder (see Figure 202-2). Standard 0.95 cm (3/8-inch) plastic tubing and compression fittings in conjunction with an adjustable pressure regulator and needle valve may be used.

3.2.2 Rotameter. Capable of measuring gas flow at 20 liters/min.

3.3 Analysis. The following equipment is necessary in addition to that listed in Method 17, section 2.3:

3.3.1 Separatory Funnel. Glass, 1-liter.

3.3.2 Weighing Tins. 350-ml.

3.3.3 Dry Equipment. Hot plate and oven with temperature control.

3.3.4 Pipets. 5-ml.

3.3.5 Ion Chromatograph. Same as in Method 5F, Section 2.1.6.

4. Reagents

Unless otherwise indicated, all reagents must conform to the specifications established by the Committee on Analytical Reagents of the American Chemical Society.

Where such specifications are not available, use the best available grade.

4.1 Sampling. Same as in Method 17, section 3.1, with the addition of deionized distilled water to conform to the American Society for Testing and Materials Specification D 1193-74, Type II and the omission of section 3.1.4.

4.2 Sample Recovery. Same as in Method 17, section 3.2, with the following additions:

4.2.1 N₂ Gas. Zero N₂ gas at delivery pressures high enough to provide a flow of 20 liters/min for 1 hour through the sampling train.

4.2.2 Methylene Chloride. ACS grade. Blanks shall be run prior to use and only methylene chloride with low blank values (0.001 percent) shall be used.

4.2.3 Water. Same as in section 4.1.

4.3 Analysis. Same as in Method 17, section 3.3, with the following additions:

4.3.1 Methylene Chloride. Same as section 4.2.2.

4.3.2 Ammonium Hydroxide. Concentrated (14.8 M) NH₄OH.

4.3.3 Water. Same as in section 4.1.

4.3.4 Phenolphthalein. The pH indicator solution, 0.05 percent in 50 percent alcohol.

5. Procedure

5.1 Sampling. Same as in Method 17, section 4.1, with the following exceptions:

5.1.1 Place 100 ml of water in the first three impingers.

5.1.2 The use of silicone grease in train assembly is not recommended because it is very soluble in MeCl₂ which may result in sample contamination. Teflon tape or similar means may be used to provide leak-free connections between glassware.

5.2 Sample Recovery. Same as in Method 17, section 4.2 with the addition of a post-test N₂ purge and specific changes in handling of individual samples as described below.

5.2.1 Post-test N₂ Purge for Sources Emitting SO₂. (Note: This step is recommended, but is optional. With little or no SO₂ is present in the gas stream, i.e., the pH of the impinger solution is greater than 4.5, purging has been found to be unnecessary.) As soon as possible after the post-test leak check, detach the probe and filter from the impinger train. Leave the ice in the impinger box to prevent removal of moisture during the purge. If necessary, add more ice during the purge to maintain the gas temperature below 20 °C. With no flow of gas through the clean purge line and fittings, attach it to the input of the impinger train (see Figure 202-2). To avoid over- or under-pressurizing the impinger array, slowly commence the N₂ gas flow through the line while simultaneously opening the meter box pump valve(s). When using the gas cylinder pressure to push the purge gas through the sample train, adjust the flow rate to 20 liters/min through the rotameter. When pulling the

purge gas through the sample train using the meter box vacuum pump, set the orifice pressure differential to ΔH_2 and maintain an overflow rate through the rotameter of less than 2 liters/min. This will guarantee that the N_2 delivery system is operating at greater than ambient pressure and prevents the possibility of passing ambient air (rather than N_2) through the impingers. Continue the purge under these conditions for 1 hour, checking the rotameter and ΔH value(s) periodically. After 1 hour, simultaneously turn off the delivery and pumping systems.

5.2.2 Sample Handling.

5.2.2.1 Container Nos. 1, 2, and 3. If filter catch is to be determined, as detailed in Method 17, section 4.2.

5.2.2.2 Container No. 4 (Impinger Contents). Measure the liquid in the first three impingers to within 1 ml using a clean graduated cylinder or by weighing it to within 0.5 g using a balance. Record the volume or weight of liquid present to be used to calculate the moisture content of the effluent gas. Quantitatively transfer this liquid into a clean sample bottle (glass or plastic); rinse each impinger and the connecting glassware, including probe extension, twice with water, recover the rinse water, and add it to the same sample bottle. Mark the liquid level on the bottle.

5.2.2.3 Container No. 5 ($MeCl_2$ Rinse). Follow the water rinses of each impinger and the connecting glassware, including the probe extension with two rinses of $MeCl_2$; save the rinse products in a clean, glass sample jar. Mark the liquid level on the jar.

5.2.2.4 Container No. 6 (Water Blank). Once during each field test, place 500 ml of water in a separate sample container.

5.2.2.5 Container No. 7 ($MeCl_2$ Blank). Once during each field test, place in a separate glass sample jar a volume of $MeCl_2$ approximately equivalent to the volume used to conduct the $MeCl_2$ rinse of the impingers.

5.3 Analysis. Record the data required on a sheet such as the one shown in Figure 202-3. Handle each sample container as follows:

5.3.1 Container Nos. 1, 2, and 3. If filter catch is analyzed, as detailed in Method 17, section 4.3.

5.3.2 Container Nos. 4 and 5. Note the level of liquid in the containers and confirm on the analytical data sheet whether leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods, subject to the approval of the Administrator, to correct the final results. Measure the liquid in Container No. 4 either volumetrically to ± 1 ml or gravimetrically to ± 0.5 g. Remove a 5-ml aliquot and set aside for later ion chromatographic (IC) analysis of sulfates. (Note: Do not use this aliquot to determine chlorides since the HCl will be evaporated during the first drying step; Section 8.2 details a procedure for this analysis.)

5.3.2.1 Extraction. Separate the organic fraction of the sample by adding the contents of Container No. 4 ($MeCl_2$) to the contents of Container No. 4 in a 1000-ml separatory funnel. After mixing, allow the aqueous and organic phases to fully separate, and drain off most of the organic/ $MeCl_2$ phase. Then add 75 ml of $MeCl_2$ to the funnel, mix well, and drain off the lower organic phase. Repeat with another 75 ml of $MeCl_2$. This extraction should yield about 250 ml of organic extract. Each time, leave a small amount of the organic/ $MeCl_2$ phase in the separatory funnel ensuring that no water is collected in the organic phase. Place the organic extract in a tared 350-ml weighing tin.

5.3.2.2 Organic Fraction Weight Determination (Organic Phase from Container Nos. 4 and 5). Evaporate the organic extract at room temperature and pressure in a laboratory hood. Following evaporation, desiccate the organic fraction for 24 hours in a desiccator containing anhydrous calcium sulfate. Weigh to a constant weight and report the results to the nearest 0.1 mg.

5.3.2.3 Inorganic Fraction Weight Determination. (Note: If NH_4Cl is to be counted as CPM, the inorganic fraction should be taken to near dryness (less than 1 ml liquid) in the oven and then allow to air dry at ambient temperature. If multiple acid emissions are suspected, the ammonia titration procedure in section 8.1 may be preferred.) Using a hot plate, or equivalent, evaporate the aqueous phase to approximately 50 ml; then, evaporate to dryness in a 105 °C oven. Redisolve the residue in 100 ml of water. Add five drops of phenolphthalein to this solution; then, add concentrated (14.8 M) NH_4OH until the sample turns pink. Any excess NH_4OH will be evaporated during the drying step. Evaporate the sample to dryness in a 105 °C oven, desiccate the sample for 24 hours, weigh to a constant weight, and record the results to the nearest 0.1 mg. (Note: The addition of NH_4OH is recommended, but is optional when little or no SO_2 is present in the gas stream, i.e., when the pH of the impinger solution is greater than 4.5, the addition of NH_4OH is not necessary.)

5.3.2.4 Analysis of Sulfate by IC to Determine Ammonium Ion (NH_4^+) Retained in the Sample. (Note: If NH_4OH is not added, omit this step.) Determine the amount of sulfate in the aliquot taken from Container No. 4 earlier as described in Method 5F (appendix A, 40 CFR part 60). Based on the IC SO_4^{2-} analysis of the aliquot, calculate the correction factor to subtract the NH_4^+ retained in the sample and to add the combined water removed by the acid-base reaction (see section 7.2).

5.3.3 Analysis of Water and $MeCl_2$ Blanks (Container Nos. 6 and 7). Analyze these sample blanks as described above in sections 5.3.2.3 and 5.3.2.2, respectively.

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5.3.4 Analysis of Acetone Blank (Container No. 8). Same as in Method 17, section 4.3.

6. Calibration

Same as in Method 17, section 5, except for the following:

6.1 IC Calibration. Same as Method 5F, section 5.

6.2 Audit Procedure. Concurrently, analyze the audit sample and a set of compliance samples in the same manner to evaluate the technique of the analyst and the standards preparation. The same analyst, analytical reagents, and analytical system shall be used both for compliance samples and the EPA audit sample. If this condition is met, auditing of subsequent compliance analyses for the same enforcement agency within 30 days is not required. An audit sample set may not be used to validate different sets of compliance samples under the jurisdiction of different enforcement agencies, unless prior arrangements are made with both enforcement agencies.

6.3 Audit Samples. Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing:

Source Test Audit Coordinator (MD-77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle, Park, NC 27711

or by calling the Source Test Audit Coordinator (STAC) at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.4 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calculations

Same as in Method 17, section 6, with the following additions:

7.1 Nomenclature. Same as in Method 17, section 6.1 with the following additions.

C_{cpm} =Concentration of the CPM in the stack gas, dry basis, corrected to standard conditions, g/dscm (g/dscf).

C_{SO_4} =Concentration of SO_4-2 in the sample, mg/ml.

m_b =Sum of the mass of the water and $MeCl_2$ blanks, mg.

m_c =Mass of the NH_4+ added to sample to form ammonium sulfate, mg.

m_i =Mass of inorganic CPM matter, mg.

m_o =Mass of organic CPM, mg.

m_r =Mass of dried sample from inorganic fraction, mg.

V_b =Volume of aliquot taken for IC analysis, ml.

V_{ic} =Volume of impinger contents sample, ml.

7.2 Correction for NH_4+ and H_2O . Calculate the correction factor to subtract the NH_4+ retained in the sample based on the IC SO_4-2 and if desired, add the combined water removed by the acid-base reaction.

$$m_c = KC_{SO_2} V_{ic} \quad \text{Eq. 202-1}$$

=0.1840, when only correcting for NH_4+ .

7.3 Mass of Inorganic CPM.

$$m_i = m_r \frac{V_{ic}}{V_{ic} - V_b} - m_c \quad \text{Eq. 202-2}$$

7.4

Concentration of CPM.

$$C_{cpm} = \frac{m_o + m_i - m_b}{VM_{std}} \quad \text{Eq. 202-3}$$

8. Alternative Procedures

8.1 Determination of NH_4+ Retained in Sample by Titration.

8.1.1 An alternative procedure to determine the amount of NH_4+ added to the inorganic fraction by titration may be used. After dissolving the inorganic residue in 100 ml of water, titrate the solution with 0.1 N $NH_4 OH$ to a pH of 7.0, as indicated by a pH meter. The 0.1 N $NH_4 OH$ is made as follows: Add 7 ml of concentrated (14.8 M) $NH_4 OH$ to 1 liter of water. Standardize against standardized 0.1 N $H_2 SO_4$ and calculate the exact normality using a procedure parallel to that described in section 5.5 of Method 6 (appendix A, 40 CFR part 60). Alternatively, purchase 0.1 N $NH_4 OH$ that has been standardized against a National Institute of Standards and Technology reference material.

8.1.2 Calculate the concentration of SO_4-2 in the sample using the following equation.

$$CSO_4 = \frac{48.03 V_t N}{100} \quad \text{Eq. 202-4}$$

where

N = Normality of the $NH_4 OH$, mg/ml.

V_t = Volume of $NH_4 OH$ titrant, ml.

48.03 = mg/meq.

100 = Volume of solution, ml.

8.3.1 Calculate the CPM as described in section 7.

8.2 Analysis of Chlorides by IC. At the conclusion of the final weighing as described in section 5.3.2.3, redissolve the inorganic fraction in 100 ml of water. Analyze an aliquot of the redissolved sample for chlorides by IC using techniques similar to those described in Method 5F for sulfates. Previous drying of the sample should have removed all HCl. Therefore, the remaining chlorides measured by IC can be assumed to be NH_4Cl , and this weight can be subtracted from the weight determined for CPM.

8.3 Air Purge to Remove SO_2 from Impinger Contents. As an alternative to the post-test N_2 purge described in section 5.2.1, the tester may opt to conduct the post-test purge with air at 20 liter/min. Note: The use of an air purge is not as effective as a N_2 purge.

8.4 Chloroform-ether Extraction. As an alternative to the methylene chloride extraction described in section 5.3.2.1, the tester may opt to conduct a chloroform-ether extraction. Note: The Chloroform-ether was not as effective as the MeCl_2 in removing the organics, but it was found to be an acceptable organic extractant. Chloroform and diethylether of ACS grade, with low blank values (0.001 percent), shall be used. Analysis of the chloroform and diethylether blanks shall be conducted according to Section 5.3.3 for MeCl_2 .

8.4.1 Add the contents of Container No. 4 to a 1000-ml separatory funnel. Then add 75 ml of chloroform to the funnel, mix well, and drain off the lower organic phase. Repeat two more times with 75 ml of chloroform. Then perform three extractions with 75 ml of diethylether. This extraction should yield approximately 450 ml of organic extraction. Each time, leave a small amount of the organic/ MeCl_2 phase in the separatory funnel ensuring that no water is collected in the organic phase.

8.4.2 Add the contents of Container No. 5 to the organic extraction. Place approximately 300 ml of the organic extract in a tared 350-ml weighing tin while storing the remaining organic extract in a sample container. As the organic extract evaporates, add the remaining extract to the weighing tin.

8.4.3 Determine the weight of the organic phase as described in Section 5.3.2.2.

8.5 Improving Collection Efficiency. If low impinger collection efficiency is suspected, the following procedure may be used.

8.5.1 Place an out-of-stock filter as described in Method 8 between the second and third impingers.

8.5.2 Recover and analyze the filter according to Method 17, Section 4.2. Include the filter holder as part of the connecting glassware and handle as described in sections 5.2.2.2 and 5.2.2.3.

8.5.3 Calculate the Concentration of CPM as follows:

$$C_{\text{cpm}} = \frac{m_o + m_i + m_f - m_b}{VM_{\text{std}}} \quad \text{Eq. 202-5}$$

where:

m_f = amount of CPM collected on out-of-stack filter, mg.

8.6 Wet Source Testing. When testing at a wet source, use a heated out-of-stack filter as described in Method 5.

9. Bibliography

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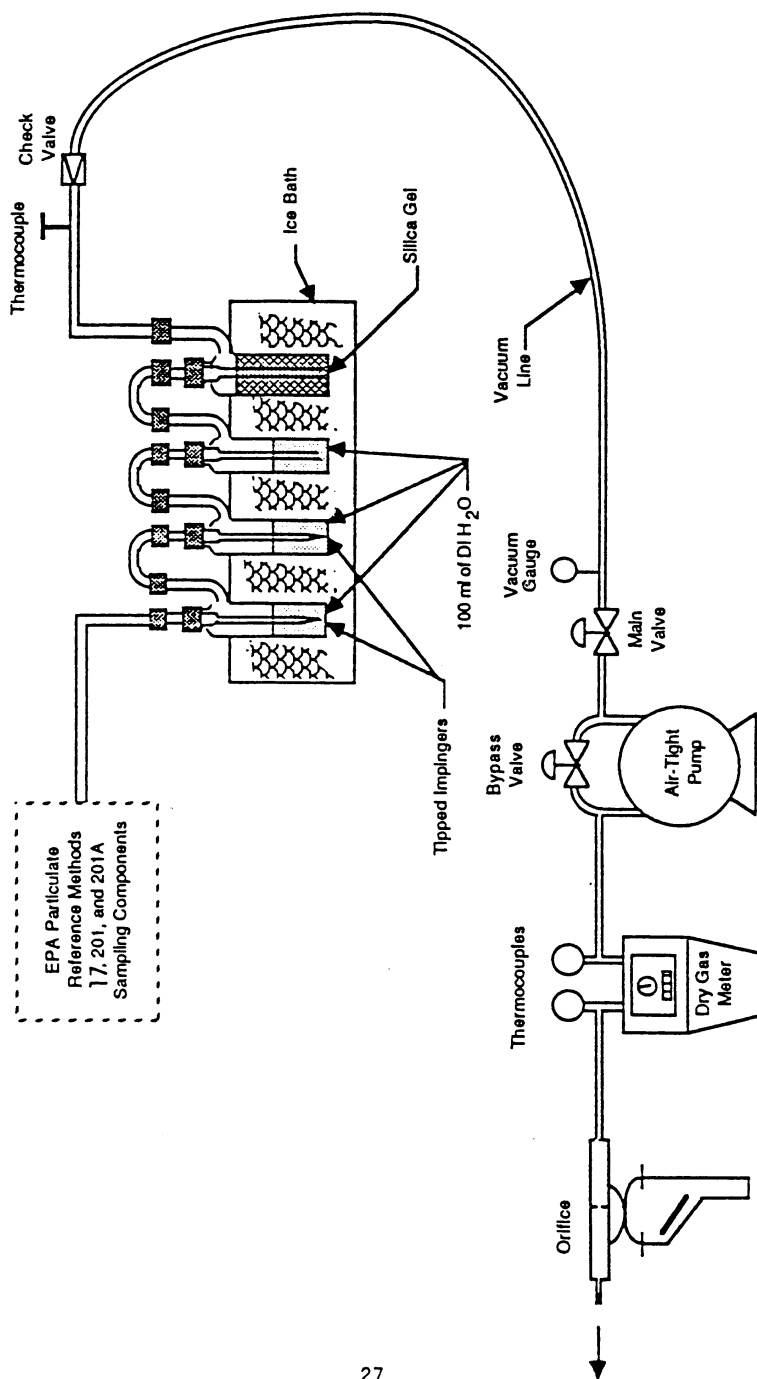


Figure 202-1. Schematic of condensible particulate sampling train.

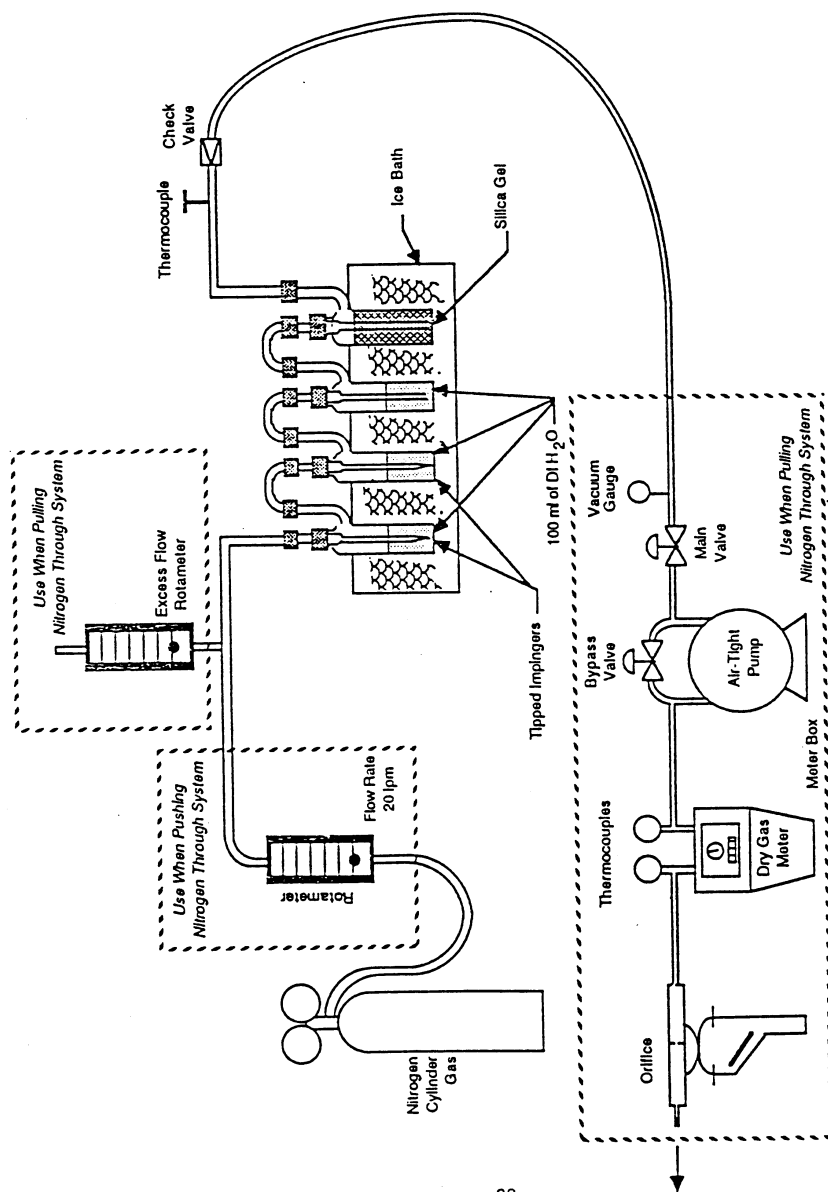


Figure 202-2. Schematic of post-test nitrogen purge system.

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Moisture Determination

Volume or weight of liquid in impingers: _____ ml or g

Weight of moisture in silica gel: _____ g

Sample Preparation (Container No. 4)

Amount of liquid lost during transport: _____ ml

Final volume: _____ ml

pH of sample prior to analysis: _____

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Addition of NH₄ OH required: _____
Sample extracted 2X with 75 ml MeCl₂?:

For Titration of Sulfate

Normality of NH₂ OH: _____ N
Volume of sample titrated: _____ ml
Volume of titrant: _____ ml

Sample Analysis

| Container number | Weight of condensible particulate, mg | | |
|-----------------------|---------------------------------------|-------------|-------------|
| | Final weight | Tare weight | Weight gain |
| 4 (Inorganic) | | | |
| 4 & 5 (Organic) | | | |

Total: _____
Less Blank: _____
Weight of Consensible Particulate:
Figure 202-3. Analytical data sheet.

METHOD 203A—VISUAL DETERMINATION OF
OPACITY OF EMISSIONS FROM STATIONARY
SOURCES FOR TIME-AVERAGED REGULA-
TIONS

1.0 Scope and Application

What is Method 203A?

Method 203A is an example test method suitable for State Implementation Plans (SIP) and is applicable to the determination of the opacity of emissions from sources of visible emissions for time-averaged regulations. A time-averaged regulation is any regulation that requires averaging visible emission data to determine the opacity of visible emissions over a specific time period.

Method 203A is virtually identical to EPA's Method 9 of 40 CFR Part 60, Appendix A, except for the data-reduction procedures, which provide for averaging times other than 6 minutes. Therefore, using Method 203A with a 6-minute averaging time would be the same as following EPA Method 9. The certification procedures for this method are identical to those provided in Method 9 and are provided here, in full, for clarity and convenience. An example visible emission observation form and instructions for its use can be found in reference 7 of Section 17 of Method 9.

2.0 Summary of Method

The opacity of emissions from sources of visible emissions is determined visually by an observer certified according to the procedures in Section 10 of this method. Readings taken every 15 seconds are averaged over a time period specified in the applicable regulation ranging from 2 minutes to 6 minutes.

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3.0 Definitions [Reserved]

4.0 Interferences [Reserved]

5.0 Safety [Reserved]

6.0 Equipment and Supplies

What equipment and supplies are needed?

6.1 *Stop Watch.* Two watches are required that provide a continuous display of time to the nearest second.

6.2 *Compass (optional).* A compass is useful for determining the direction of the emission point from the spot where the visible emissions (VE) observer stands and for determining the wind direction at the source. For accurate readings, the compass should be magnetic with resolution better than 10 degrees. It is suggested that the compass be jewel-mounted and liquid-filled to dampen the needle swing; map reading compasses are excellent.

6.3 *Range Finder (optional).* Range finders determine distances from the observer to the emission point. The instrument should measure a distance of 1000 meters with a minimum accuracy of ± 10 percent.

6.4 *Abney Level (optional).* This device for determining the vertical viewing angle should measure within 5 degrees.

6.5 *Sling Psychrometer (optional).* In case of the formation of a steam plume, a wet- and dry-bulb thermometer, accurate to 0.5 °C, are mounted on a sturdy assembly and swung rapidly in the air in order to determine the relative humidity.

6.6 *Binoculars (optional).* Binoculars are recommended to help identify stacks and to characterize the plume. An 8 x 50 or 10 x 50 magnification, color-corrected coated lenses and rectilinear field of view is recommended.

6.7 *Camera (optional).* A camera is often used to document the emissions before and after the actual opacity determination.

6.8 *Safety Equipment.* The following safety equipment, which should be approved by the Occupational Safety and Health Association (OSHA), is recommended: orange or yellow hard hat, eye and ear protection, and steel-toed safety boots.

6.9 *Clipboard and Accessories (optional).* A clipboard, several ball-point pens (black ink recommended), a rubber band, and several visible emission observation forms facilitate documentation.

7.0 Reagents and Standards [Reserved]

8.0 Sample Collection, Preservation, Storage,
and Transport

What is the Test Procedure?

An observer qualified in accordance with Section 10 of this method must use the following procedures to visually determine the opacity of emissions from stationary sources.

8.1 Procedure for Emissions from Stacks. These procedures are applicable for visually determining the opacity of stack emissions by a qualified observer.

8.1.1 Position. You must stand at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140-degree sector to your back. Consistent with maintaining the above requirement as much as possible, you must make opacity observations from a position such that the line of vision is approximately perpendicular to the plume direction, and when observing opacity of emissions from rectangular outlets (*e.g.*, roof monitors, open baghouses, non-circular stacks), approximately perpendicular to the longer axis of the outlet. You should not include more than one plume in the line of sight at a time when multiple plumes are involved and, in any case, make opacity observations with the line of sight perpendicular to the longer axis of such a set of multiple stacks (*e.g.*, stub stacks on baghouses).

8.1.2 Field Records. You must record the name of the plant, emission location, type of facility, observer's name and affiliation, a sketch of the observer's position relative to the source, and the date on a field data sheet. An example visible emission observation form can be found in reference 7 of Section 17 of this method. You must record the time, estimated distance to the emission location, approximate wind direction, estimated wind speed, description of the sky condition (presence and color of clouds), and plume background on the field data sheet at the time opacity readings are initiated and completed.

8.1.3 Observations. You must make opacity observations at the point of greatest opacity in that portion of the plume where condensed water vapor is not present. Do not look continuously at the plume but, instead, observe the plume momentarily at 15-second intervals.

8.1.3.1 Attached Steam Plumes. When condensed water vapor is present within the plume as it emerges from the emission outlet, you must make opacity observations beyond the point in the plume at which condensed water vapor is no longer visible. You must record the approximate distance from the emission outlet to the point in the plume at which the observations are made.

8.1.3.2 Detached Steam Plumes. When water vapor in the plume condenses and becomes visible at a distinct distance from the emission outlet, you must make the opacity observation at the emission outlet prior to the condensation of water vapor and the formation of the steam plume.

8.2 Recording Observations. You must record the opacity observations to the nearest 5 percent every 15 seconds on an observational record sheet such as the example visible emission observation form in reference 7 of Section 17 of this method. Each observa-

tion recorded represents the average opacity of emissions for a 15-second period. The overall length of time for which observations are recorded must be appropriate to the averaging time specified in the applicable regulation.

9.0 Quality Control [Reserved]

10.0 Calibration and Standardization

10.1 What are the Certification Requirements? To receive certification as a qualified observer, you must be trained and knowledgeable on the procedures in Section 8.0 of this method, be tested and demonstrate the ability to assign opacity readings in 5 percent increments to 25 different black plumes and 25 different white plumes, with an error not to exceed 15 percent opacity on any one reading and an average error not to exceed 7.5 percent opacity in each category. You must be tested according to the procedures described in Section 10.2 of this method. Any smoke generator used pursuant to Section 10.2 of this method must be equipped with a smoke meter which meets the requirements of Section 10.3 of this method. Certification tests that do not meet the requirements of Sections 10.2 and 10.3 of this method are not valid.

The certification must be valid for a period of 6 months, and after each 6-month period, the qualification procedures must be repeated by an observer in order to retain certification.

10.2 What is the Certification Procedure? The certification test consists of showing the candidate a complete run of 50 plumes, 25 black plumes and 25 white plumes, generated by a smoke generator. Plumes must be presented in random order within each set of 25 black and 25 white plumes. The candidate assigns an opacity value to each plume and records the observation on a suitable form. At the completion of each run of 50 readings, the score of the candidate is determined. If a candidate fails to qualify, the complete run of 50 readings must be repeated in any retest. The smoke test may be administered as part of a smoke school or training program, and may be preceded by training or familiarization runs of the smoke generator during which candidates are shown black and white plumes of known opacity.

10.3 Smoke Generator.

10.3.1 What are the Smoke Generator Specifications? Any smoke generator used for the purpose of Section 10.2 of this method must be equipped with a smoke meter installed to measure opacity across the diameter of the smoke generator stack. The smoke meter output must display in-stack opacity, based upon a path length equal to the stack exit diameter on a full 0 to 100 percent chart recorder scale. The smoke meter optical design and performance must meet the specifications shown in Table 203A-1 of this method.

The smoke meter must be calibrated as prescribed in Section 10.3.2 of this method prior to conducting each smoke reading test. At the completion of each test, the zero and span drift must be checked and, if the drift exceeds ± 1 percent opacity, the condition must be corrected prior to conducting any subsequent test runs. The smoke meter must be demonstrated at the time of installation to meet the specifications listed in Table 203A–1 of this method. This demonstration must be repeated following any subsequent repair or replacement of the photocell or associated electronic circuitry including the chart recorder or output meter, or every 6 months, whichever occurs first.

10.3.2 How is the Smoke Meter Calibrated? The smoke meter is calibrated after allowing a minimum of 30 minutes warm-up by alternately producing simulated opacity of 0 percent and 100 percent. When a stable response at 0 percent or 100 percent is noted, the smoke meter is adjusted to produce an output of 0 percent or 100 percent, as appropriate. This calibration must be repeated until stable 0 percent and 100 percent readings are produced without adjustment. Simulated 0 percent and 100 percent opacity values may be produced by alternately switching the power to the light source on and off while the smoke generator is not producing smoke.

10.3.3 How is the Smoke Meter Evaluated? The smoke meter design and performance are to be evaluated as follows:

10.3.3.1 Light Source. You must verify from manufacturer's data and from voltage measurements made at the lamp, as installed, that the lamp is operated within 5 percent of the nominal rated voltage.

10.3.3.2 Spectral Response of the Photocell. You must verify from manufacturer's data that the photocell has a photopic response; *i.e.*, the spectral sensitivity of the cell must closely approximate the standard spectral-luminosity curve for photopic vision which is referenced in (b) of Table 203A–1 of this method.

10.3.3.3 Angle of View. You must check construction geometry to ensure that the total angle of view of the smoke plume, as seen by the photocell, does not exceed 15 degrees. Calculate the total angle of view as follows:

$$\phi_v = 2 \tan^{-1} (d/2L)$$

Where:

ϕ_v = Total angle of view

d = The photocell diameter + the diameter of the limiting aperture

L = Distance from the photocell to the limiting aperture.

The limiting aperture is the point in the path between the photocell and the smoke plume where the angle of view is most restricted. In smoke generator smoke meters, this is normally an orifice plate.

10.3.3.4 Angle of Projection. You must check construction geometry to ensure that the total angle of projection of the lamp on the smoke plume does not exceed 15 degrees. Calculate the total angle of projection as follows:

$$\phi_p = 2 \tan^{-1} (d/2L)$$

Where:

ϕ_p = Total angle of projection

d = The sum of the length of the lamp filament + the diameter of the limiting aperture

L = The distance from the lamp to the limiting aperture.

10.3.3.5 Calibration Error. Using neutral-density filters of known opacity, you must check the error between the actual response and the theoretical linear response of the smoke meter. This check is accomplished by first calibrating the smoke meter according to Section 10.3.2 of this method and then inserting a series of three neutral-density filters of nominal opacity of 20, 50, and 75 percent in the smoke meter path length. Use filters calibrated within 2 percent. Care should be taken when inserting the filters to prevent stray light from affecting the meter. Make a total of five non-consecutive readings for each filter. The maximum opacity error on any one reading shall be ± 3 percent.

10.3.3.6 Zero and Span Drift. Determine the zero and span drift by calibrating and operating the smoke generator in a normal manner over a 1-hour period. The drift is measured by checking the zero and span at the end of this period.

10.3.3.7 Response Time. Determine the response time by producing the series of five simulated 0 percent and 100 percent opacity values and observing the time required to reach stable response. Opacity values of 0 percent and 100 percent may be simulated by alternately switching the power to the light source off and on while the smoke generator is not operating.

11.0 Analytical Procedures [Reserved]

12.0 Data Analysis and Calculations

12.1 Time-Averaged Regulations. A set of observations is composed of an appropriate number of consecutive observations determined by the averaging time specified (*i.e.*, 8 observations for a two minute average). Divide the recorded observations into sets of appropriate time lengths for the specified averaging time. Sets must consist of consecutive observations; however, observations immediately preceding and following interrupted observations shall be deemed consecutive. Sets need not be consecutive in time and in no case shall two sets overlap. For each set of observations, calculate the average opacity by summing the opacity readings taken over the appropriate time period and dividing by the number of readings.

For example, for a 2-minute average, eight consecutive readings would be averaged by adding the eight readings and dividing by eight.

13.0 Method Performance

13.1 Time-averaging Performances. The accuracy of test procedures for time-averaged regulations was evaluated through field studies that compare the opacity readings to a transmissometer. Analysis of these data shows that, as the time interval for averaging increases, the positive error decreases. For example, over a 2-minute time period, 90 percent of the results underestimated opacity or overestimated opacity by less than 9.5 percent opacity, while over a 6-minute time period, 90 percent of the data have less than a 7.5 percent positive error. Overall, the field studies demonstrated a negative bias. Over a 2-minute time period, 57 percent of the data have zero or negative error, and over a 6-minute time period, 58 percent of the data have zero or negative error. This means that observers are more likely to assign opacity values that are below, rather than above, the actual opacity value. Consequently, a larger percentage of noncompliance periods will be reported as compliant periods rather than compliant periods reported as violations. Table 203A-2 highlights the precision data results from the June 1985 report: "Opacity Errors for Averaging and Non Averaging Data Reduction and Reporting Techniques."

14.0 Pollution Prevention [Reserved]

15.0 Waste Management [Reserved]

16.0 Alternative Procedures [Reserved]

17.0 References

1. *U.S. Environmental Protection Agency. Standards of Performance for New Stationary Sources; Appendix A; Method 9 for Visual Determination of the Opacity of*

Emissions from Stationary Sources. Final Rule. 39 FR 219. Washington, DC. U.S. Government Printing Office. November 12, 1974.

2. *Office of Air and Radiation. "Quality Assurance Guideline for Visible Emission Training Programs." EPA-600/S4-83-011. Quality Assurance Division. Research Triangle Park, NC. May 1982.*

3. *Office of Research and Development. "Method 9—Visible Determination of the Opacity of Emissions from Stationary Sources." February 1984. Quality Assurance Handbook for Air Pollution Measurement Systems. Volume III, Section 3.1.2. Stationary Source Specific Methods. EPA-600-4-77-027b. August 1977. Office of Research and Development Publications, 26 West Clair Street, Cincinnati, OH.*

4. *Office of Air Quality Planning and Standards. "Opacity Error for Averaging and Non-averaging Data Reduction and Reporting Techniques." Final Report-SR-1-6-85. Emission Measurement Branch, Research Triangle Park, NC. June 1985.*

5. *U.S. Environmental Protection Agency. Preparation, Adoption, and Submittal of State Implementation Plans. Methods for Measurement of PM₁₀ Emissions from Stationary Sources. Final Rule. FEDERAL REGISTER. Washington, DC. U.S. Government Printing Office. Volume 55, No. 74. Pages 14246-14279. April 17, 1990.*

6. *Office of Air Quality Planning and Standards. "Collaborative Study of Opacity Observations of Fugitive Emissions from Unpaved Roads by Certified Observers." Emission Measurement Branch, Research Triangle Park, NC. October 1986.*

7. *Office of Air Quality Planning and Standards. "Field Data Forms and Instructions for EPA Methods 203A, 203B, and 203C." EPA 455/R-93-005. Stationary Source Compliance Division, Washington, DC, June 1993.*

18.0 Tables, Diagrams, Flowcharts, and Validation Data

TABLE 203A-1—SMOKE METER DESIGN AND PERFORMANCE SPECIFICATIONS

| Parameter | Specification |
|---|--|
| a. Light Source | Incandescent lamp operated at nominal rated voltage. |
| b. Spectral response of photocell | Photopic (daylight spectral response of the human eye—Citation 3). |
| c. Angle of view | 15° maximum total angle. |
| d. Angle of projection | 15° maximum total angle. |
| e. Calibration error | ±3% opacity, maximum. |
| f. Zero and span drift | ±1% opacity, 30 minutes |
| g. Response time | 5 seconds. |

TABLE 203A-2—PRECISION BETWEEN OBSERVERS: OPACITY AVERAGING

| Averaging period | Number of observations | Standard deviation (% opacity) | Amount with <7.5% opacity difference |
|------------------|------------------------|--------------------------------|--------------------------------------|
| 15-second | 140,250 | 3.4 | 87 |
| 2 minutes | 17,694 | 2.6 | 92 |
| 3 minutes | 11,836 | 2.4 | 92 |

TABLE 203A–2—PRECISION BETWEEN OBSERVERS: OPACITY AVERAGING—Continued

| Averaging period | Number of observations | Standard deviation (% opacity) | Amount with <7.5% opacity difference |
|------------------|------------------------|--------------------------------|--------------------------------------|
| 6 minutes | 5,954 | 2.1 | 93 |

METHOD 203B—VISUAL DETERMINATION OF OPACITY OF EMISSIONS FROM STATIONARY SOURCES FOR TIME-EXCEPTION REGULATIONS

1.0 Scope and Application

What is Method 203B?

Method 203B is an example test method suitable for State Implementation Plans (SIPs) and is applicable to the determination of the opacity of emissions from sources of visible emissions for time-exception regulations. A time-exception regulation means any regulation that allows predefined periods of opacity above the otherwise applicable opacity limit (*e.g.*, allowing exceedances of 20 percent opacity for 3 minutes in 1 hour.)

Method 203B is virtually identical to EPA's Method 9 of 40 CFR part 60, Appendix A, except for the data-reduction procedures, which have been modified to apply to time-exception regulations. The certification procedures for this method are identical to those provided in Method 9. An example of a visible emission observation form and instructions for its use can be found in reference 7 of Section 17 of Method 203A.

2.0 Summary of Method

The opacity of emissions from sources of visible emissions is determined visually by a qualified observer.

3.0 Definitions [Reserved]

4.0 Interferences [Reserved]

5.0 Safety [Reserved]

6.0 Equipment and Supplies

What equipment and supplies are needed?

The same as specified in Section 6.0 of Method 203A.

7.0 Reagents and Standards [Reserved]

8.0 Sample Collection, Preservation, Storage, and Transport

What is the Test Procedure?

The observer qualified in accordance with Section 10 of Method 203A must use the following procedures for visually determining the opacity of emissions.

8.1 Procedures for Emissions From Stationary Sources. The procedures for emissions

from stationary sources are the same as specified in 8.1 of Method 203A.

8.2 Recording Observations. You must record opacity observations to the nearest 5 percent at 15-second intervals on an observational record sheet. Each observation recorded represents the average opacity of emissions for a 15-second period. The overall length of time for which observations are recorded must be appropriate to the applicable regulation.

9.0 Quality Control [Reserved]

10.0 Calibration and Standardization

The Calibration and Standardization requirements are the same as specified in Section 10 of Method 203A.

11.0 Analytical Procedures [Reserved]

12.0 Data Analysis and Calculations

Data Reduction for Time-Exception Regulations. For a time-exception regulation, reduce opacity observations as follows: Count the number of observations above the applicable standard and multiply that number by 0.25 to determine the minutes of emissions above the target opacity.

13.0 Method Performance

13.1 Time-Exception Regulations. "Opacity Errors for Averaging and Non-Averaging Data Reduction and Reporting Techniques" analyzed the time errors associated with false compliance or false non-compliance determinations resulting from a sample of 1110 opacity readings with 6-minute observation periods. The study applied a 20 percent opacity standard. Fifty-one percent of the data showed zero error in time determinations. The standard deviation was 97.5 seconds for the 6-minute time period.

13.1.1 Overall, the study showed a negative bias. Each reading is associated with a 15-second block of time. The readings were multiplied by 15 seconds and the resulting time spent above the standard was compared to the transmissometer results. The average amount of time that observations deviated from the transmissometer's determinations was –8.3 seconds. Seventy percent of the time determinations were either correct or underestimated the time of excess emissions. Consequently, a larger percentage of noncompliance periods would be reported as compliant periods rather than compliant periods reported as violations.

13.1.2 *Some time-exception regulations reduce the data by averaging over 1-minute periods and then counting those minutes above the standard.* This data reduction procedure results in a less stringent standard than determinations resulting from data reduction procedures of Method 203B.

14.0 Pollution Prevention [Reserved]

15.0 Waste Management [Reserved]

16.0 Alternative Procedures [Reserved]

17.0 References

The references are the same as specified in Section 17 of Method 203A.

18.0 Tables, Diagrams, Flowcharts, and Validation Data [Reserved]

METHOD 203C—VISUAL DETERMINATION OF OPACITY OF EMISSIONS FROM STATIONARY SOURCES FOR INSTANTANEOUS LIMITATION REGULATIONS

1.0 Scope and Application

What is Method 203C?

Method 203C is an example test method suitable for State Implementation Plans (SIPs) and is applicable to the determination of the opacity of emissions from sources of visible emissions for regulations with an instantaneous opacity limitation. An instantaneous opacity limitation is an opacity limit which is never to be exceeded.

Method 203C is virtually identical to EPA's Method 9 of 40 CFR Part 60, Appendix A, except for 5-second reading intervals and the data-reduction procedures, which have been modified for instantaneous limitation regulations. The certification procedures for this method are virtually identical to Method 9. An example visible emission observation form and instructions for its use can be found in reference 7 of Section 17 of Method 203A.

2.0 Summary of Method

The opacity of emissions from sources of visible emissions is determined visually by an observer certified according to the procedures in Section 10 of Method 203A.

3.0 Definitions [Reserved]

4.0 Interferences [Reserved]

5.0 Safety [Reserved]

6.0 Equipment and Supplies

The equipment and supplies used are the same as Section 6.0 of Method 203A.

7.0 Reagents and Standards [Reserved]

8.0 Sample Collection, Preservation, Storage, and Transport

What is the Test Procedure?

The qualified observer must use the following procedures for visually determining the opacity of emissions.

8.1 *Procedures for Emissions From Stationary Sources.* These are the same as Section 8.1 of Method 203A.

8.1.1 *Position.* Same as Section 8.1.1 of Method 203A.

8.1.2 *Field Records.* Same as Section 8.1.2 of Method 203A.

8.1.3 *Observations.* Make opacity observations at the point of greatest opacity in that portion of the plume where condensed water vapor is not present. Do not look continuously at the plume, instead, observe the plume momentarily at 5-second intervals.

8.1.3.1 *Attached Steam Plumes.* Same as Section 8.1.3.1 of Method 203A.

8.1.3.2 *Detached Steam Plumes.* Same as Section 8.1.3.2 of Method 203A.

8.2 *Recording Observations.* You must record opacity observations to the nearest 5 percent at 5-second intervals on an observational record sheet. Each observation recorded represents the average of emissions for the 5-second period. The overall time for which recordings are made must be of a length appropriate to the applicable regulation for which opacity is being measured.

9.0 Quality Control [Reserved]

10.0 Calibration and Standardization

The calibration and standardization procedures are the same as Section 10 of Method 203A.

11.0 Analytical Procedures [Reserved]

12.0 Data Analysis and Calculations

12.1 *Data Reduction for Instantaneous Limitation Regulations.* For an instantaneous limitation regulation, a 1-minute averaging time will be used. You must divide the observations recorded on the record sheet into sets of consecutive observations. A set is composed of the consecutive observations made in 1 minute. Sets need not be consecutive in time, and in no case must two sets overlap. You must reduce opacity observations by dividing the sum of all observations recorded in a set by the number of observations recorded in each set.

12.2 *Reduce opacity observations by averaging 12 consecutive observations recorded at 5-second intervals.* Divide the observations recorded on the record sheet into sets of 12 consecutive observations. For each set of 12 observations, calculate the average by summing the opacity of the 12 observations and dividing this sum by 12.

13.0 Method Performance

The results of the “Collaborative Study of Opacity Observations at Five-second Intervals by Certified Observers” are almost identical to those of previous studies of Method 9 observations taken at 15-second intervals and indicate that observers can make valid observations at 5-second intervals. The average difference of all observations from the transmissometer values was 8.8 percent opacity, which shows a fairly high negative bias. Underestimating the opacity of the visible emissions is more likely than overestimating the opacity of the emissions.

14.0 Pollution Prevention [Reserved]

15.0 Waste Management [Reserved]

16.0 Alternative Procedures [Reserved]

17.0 References

The references are the same as references 1–7 in Method 203A in addition to the following:

1. Office of Air Quality Planning and Standards. “Collaborative Study of Opacity Observations at Five-second Intervals by Certified Observers.” Docket A-84-22, IV-A-2. Emission Measurement Branch, Research Triangle Park, N.C. September 1990.

18.0 Tables, Diagrams, Flowcharts, and Validation Data

METHOD 204—CRITERIA FOR AND VERIFICATION OF A PERMANENT OR TEMPORARY TOTAL ENCLOSURE

1. Scope and Application

This procedure is used to determine whether a permanent or temporary enclosure meets the criteria for a total enclosure. An existing building may be used as a temporary or permanent enclosure as long as it meets the appropriate criteria described in this method.

2. Summary of Method

An enclosure is evaluated against a set of criteria. If the criteria are met and if all the exhaust gases from the enclosure are ducted to a control device, then the volatile organic compounds (VOC) capture efficiency (CE) is assumed to be 100 percent, and CE need not be measured. However, if part of the exhaust gas stream is not ducted to a control device, CE must be determined.

3. Definitions

3.1 Natural Draft Opening (NDO). Any permanent opening in the enclosure that remains open during operation of the facility and is not connected to a duct in which a fan is installed.

3.2 Permanent Total Enclosure (PE). A permanently installed enclosure that com-

pletely surrounds a source of emissions such that all VOC emissions are captured and contained for discharge to a control device.

3.3 Temporary Total Enclosure (TTE). A temporarily installed enclosure that completely surrounds a source of emissions such that all VOC emissions that are not directed through the control device (i.e. uncaptured) are captured by the enclosure and contained for discharge through ducts that allow for the accurate measurement of the uncaptured VOC emissions.

3.4 Building Enclosure (BE). An existing building that is used as a TTE.

4. Safety

An evaluation of the proposed building materials and the design for the enclosure is recommended to minimize any potential hazards.

5. Criteria for Temporary Total Enclosure

5.1 Any NDO shall be at least four equivalent opening diameters from each VOC emitting point unless otherwise specified by the Administrator.

5.2 Any exhaust point from the enclosure shall be at least four equivalent duct or hood diameters from each NDO.

5.3 The total area of all NDO's shall not exceed 5 percent of the surface area of the enclosure's four walls, floor, and ceiling.

5.4 The average facial velocity (FV) of air through all NDO's shall be at least 3,600 m/hr (200 fpm). The direction of air flow through all NDO's shall be into the enclosure.

5.5 All access doors and windows whose areas are not included in section 5.3 and are not included in the calculation in section 5.4 shall be closed during routine operation of the process.

6. Criteria for a Permanent Total Enclosure

6.1 Same as sections 5.1 and 5.3 through 5.5.

6.2 All VOC emissions must be captured and contained for discharge through a control device.

7. Quality Control

7.1 The success of this method lies in designing the TTE to simulate the conditions that exist without the TTE (i.e., the effect of the TTE on the normal flow patterns around the affected facility or the amount of uncaptured VOC emissions should be minimal). The TTE must enclose the application stations, coating reservoirs, and all areas from the application station to the oven. The oven does not have to be enclosed if it is under negative pressure. The NDO's of the temporary enclosure and an exhaust fan must be properly sized and placed.

7.2 Estimate the ventilation rate of the TTE that best simulates the conditions that exist without the TTE (i.e., the effect of the

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TTE on the normal flow patterns around the affected facility or the amount of uncaptured VOC emissions should be minimal). Figure 204-1 or the following equation may be used as an aid.

$$CE = \frac{Q_G C_G}{Q_G C_G + Q_F C_F} \quad \text{Eq. 204-1}$$

Measure the concentration (C_G) and flow rate (Q_G) of the captured gas stream, specify a safe concentration (C_F) for the uncaptured gas stream, estimate the CE, and then use the plot in Figure 204-1 or Equation 204-1 to determine the volumetric flow rate of the uncaptured gas stream (Q_F). An exhaust fan that has a variable flow control is desirable.

7.3 Monitor the VOC concentration of the captured gas stream in the duct before the capture device without the TTE. To minimize the effect of temporal variation on the captured emissions, the baseline measurement should be made over as long a time period as practical. However, the process conditions must be the same for the measurement in section 7.5 as they are for this baseline measurement. This may require short measuring times for this quality control check before and after the construction of the TTE.

7.4 After the TTE is constructed, monitor the VOC concentration inside the TTE. This concentration should not continue to increase, and must not exceed the safe level according to Occupational Safety and Health Administration requirements for permissible exposure limits. An increase in VOC concentration indicates poor TTE design.

7.5 Monitor the VOC concentration of the captured gas stream in the duct before the capture device with the TTE. To limit the effect of the TTE on the process, the VOC concentration with and without the TTE must be within 10 percent. If the measurements do not agree, adjust the ventilation rate from the TTE until they agree within 10 percent.

8. Procedure

8.1 Determine the equivalent diameters of the NDO's and determine the distances from each VOC emitting point to all NDO's. Determine the equivalent diameter of each exhaust duct or hood and its distance to all NDO's. Calculate the distances in terms of

equivalent diameters. The number of equivalent diameters shall be at least four.

8.2 Measure the total surface area (A_T) of the enclosure and the total area (A_N) of all NDO's in the enclosure. Calculate the NDO to enclosure area ratio (NEAR) as follows:

$$NEAR = \frac{A_N}{A_T} \quad \text{Eq. 204-2}$$

The NEAR must be ≤ 10.05 .

8.3 Measure the volumetric flow rate, corrected to standard conditions, of each gas stream exiting the enclosure through an exhaust duct or hood using EPA Method 2. In some cases (e.g., when the building is the enclosure), it may be necessary to measure the volumetric flow rate, corrected to standard conditions, of each gas stream entering the enclosure through a forced makeup air duct using Method 2. Calculate FV using the following equation:

$$FV = \frac{Q_O - Q_I}{A_N} \quad \text{Eq. 204-3}$$

where:

Q_O = the sum of the volumetric flow from all gas streams exiting the enclosure through an exhaust duct or hood.

Q_I = the sum of the volumetric flow from all gas streams into the enclosure through a forced makeup air duct; zero, if there is no forced makeup air into the enclosure.

A_N = total area of all NDO's in enclosure.

The FV shall be at least 3,600 m/hr (200 fpm). Alternatively, measure the pressure differential across the enclosure. A pressure drop of 0.013 mm Hg (0.007 in. H_2O) corresponds to an FV of 3,600 m/hr (200 fpm).

8.4 Verify that the direction of air flow through all NDO's is inward. If FV is less than 9,000 m/hr (500 fpm), the continuous inward flow of air shall be verified using streamers, smoke tubes, or tracer gases. Monitor the direction of air flow for at least 1 hour, with checks made no more than 10 minutes apart. If FV is greater than 9,000 m/hr (500 fpm), the direction of air flow through the NDOs shall be presumed to be inward at all times without verification.

9. Diagrams

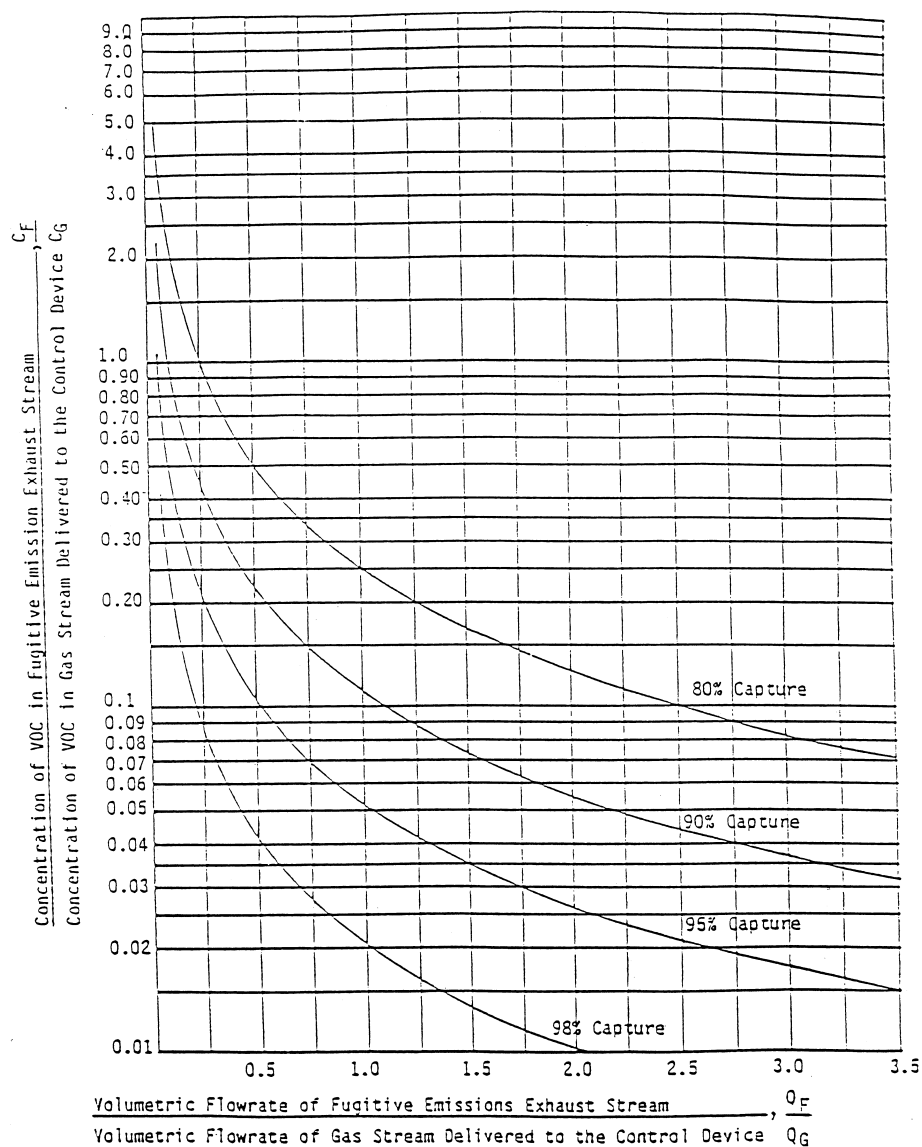


Figure 204-1. The crumpler chart.

METHOD 204A—VOLATILE ORGANIC COMPOUNDS CONTENT IN LIQUID INPUT STREAM

1. Scope and Application

1.1 Applicability. This procedure is applicable for determining the input of volatile organic compounds (VOC). It is intended to be used in the development of liquid/gas pro-

cedures for determining VOC capture efficiency (CE) for surface coating and printing operations.

1.2 Principle. The amount of VOC introduced to the process (L) is the sum of the products of the weight (W) of each VOC containing liquid (ink, paint, solvent, etc.) used and its VOC content (V).

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

The amount of VOC containing liquid introduced to the process is determined as the weight difference of the feed material before and after each sampling run. The VOC content of the liquid input material is determined by volatilizing a small aliquot of the material and analyzing the volatile material using a flame ionization analyzer (FIA). A sample of each VOC containing liquid is analyzed with an FIA to determine V.

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Liquid Weight.

4.1.1 Balances/Digital Scales. To weigh drums of VOC containing liquids to within 0.2 lb or 1.0 percent of the total weight of VOC liquid used.

4.1.2 Volume Measurement Apparatus (Alternative). Volume meters, flow meters, density measurement equipment, etc., as needed to achieve the same accuracy as direct weight measurements.

4.2 VOC Content (FIA Technique). The liquid sample analysis system is shown in Figures 204A-1 and 204A-2. The following equipment is required:

4.2.1 Sample Collection Can. An appropriately-sized metal can to be used to collect VOC containing materials. The can must be constructed in such a way that it can be grounded to the coating container.

4.2.2 Needle Valves. To control gas flow.

4.2.3 Regulators. For carrier gas and calibration gas cylinders.

4.2.4 Tubing. Teflon or stainless steel tubing with diameters and lengths determined by connection requirements of equipment. The tubing between the sample oven outlet and the FIA shall be heated to maintain a temperature of $120 \pm 5^\circ\text{C}$.

4.2.5 Atmospheric Vent. A tee and 0- to 0.5-liter/min rotameter placed in the sampling line between the carrier gas cylinder and the VOC sample vessel to release the excess carrier gas. A toggle valve placed be-

tween the tee and the rotameter facilitates leak tests of the analysis system.

4.2.6 Thermometer. Capable of measuring the temperature of the hot water bath to within 1°C .

4.2.7 Sample Oven. Heated enclosure, containing calibration gas coil heaters, critical orifice, aspirator, and other liquid sample analysis components, capable of maintaining a temperature of $120 \pm 5^\circ\text{C}$.

4.2.8 Gas Coil Heaters. Sufficient lengths of stainless steel or Teflon tubing to allow zero and calibration gases to be heated to the sample oven temperature before entering the critical orifice or aspirator.

4.2.9 Water Bath. Capable of heating and maintaining a sample vessel temperature of $100 \pm 5^\circ\text{C}$.

4.2.10 Analytical Balance. To measure ± 0.001 g.

4.2.11 Disposable Syringes. 2-cc or 5-cc.

4.2.12 Sample Vessel. Glass, 40-ml septum vial. A separate vessel is needed for each sample.

4.2.13 Rubber Stopper. Two-hole stopper to accommodate 3.2-mm ($\frac{1}{8}$ -in.) Teflon tubing, appropriately sized to fit the opening of the sample vessel. The rubber stopper should be wrapped in Teflon tape to provide a tighter seal and to prevent any reaction of the sample with the rubber stopper. Alternatively, any leak-free closure fabricated of nonreactive materials and accommodating the necessary tubing fittings may be used.

4.2.14 Critical Orifices. Calibrated critical orifices capable of providing constant flow rates from 50 to 250 ml/min at known pressure drops. Sapphire orifice assemblies (available from O'Keefe Controls Company) and glass capillary tubing have been found to be adequate for this application.

4.2.15 Vacuum Gauge. Zero to 760-mm (0- to 30-in.) Hg U-Tube manometer or vacuum gauge.

4.2.16 Pressure Gauge. Bourdon gauge capable of measuring the maximum air pressure at the aspirator inlet (e.g., 100 psig).

4.2.17 Aspirator. A device capable of generating sufficient vacuum at the sample vessel to create critical flow through the calibrated orifice when sufficient air pressure is present at the aspirator inlet. The aspirator must also provide sufficient sample pressure to operate the FIA. The sample is also mixed with the dilution gas within the aspirator.

4.2.18 Soap Bubble Meter. Of an appropriate size to calibrate the critical orifices in the system.

4.2.19 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated that they would provide more accurate measurements. The FIA instrument should be the same instrument used in the gaseous analyses adjusted with the same

fuel, combustion air, and sample back-pressure (flow rate) settings. The system shall be capable of meeting or exceeding the following specifications:

4.2.19.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.2.19.2 Calibration Drift. Less than ± 3.0 percent of the span value.

4.2.19.3 Calibration Error. Less than ± 5.0 percent of the calibration gas value.

4.2.20 Integrator/Data Acquisition System. An analog or digital device or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data. The minimum data sampling frequency for computing average or integrated values is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2.21 Chart Recorder (Optional). A chart recorder or similar device is recommended to provide a continuous analog display of the measurement results during the liquid sample analysis.

5. Reagents and Standards

5.1 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.1.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H₂/60 percent He or 40 percent H₂/60 percent N₂ gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.1.2 Carrier Gas. High purity air with less than 1 ppm of organic material (as propane) or less than 0.1 percent of the span value, whichever is greater.

5.1.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentrations of 20–30, 45–55, and 70–80 percent of the span value in air, respectively. Other calibration values and other span values may be used if it can be shown to the Administrator's

satisfaction that equally accurate measurements would be achieved.

5.1.4 System Calibration Gas. Gas mixture standard containing propane in air, approximating the undiluted VOC concentration expected for the liquid samples.

6. Sample Collection, Preservation and Storage

6.1 Samples must be collected in a manner that prevents or minimizes loss of volatile components and that does not contaminate the coating reservoir.

6.2 Collect a 100-ml or larger sample of the VOC containing liquid mixture at each application location at the beginning and end of each test run. A separate sample should be taken of each VOC containing liquid added to the application mixture during the test run. If a fresh drum is needed during the sampling run, then obtain a sample from the fresh drum.

6.3 When collecting the sample, ground the sample container to the coating drum. Fill the sample container as close to the rim as possible to minimize the amount of headspace.

6.4 After the sample is collected, seal the container so the sample cannot leak out or evaporate.

6.5 Label the container to clearly identify the contents.

7. Quality Control

7.1 Required instrument quality control parameters are found in the following sections:

7.1.1 The FIA system must be calibrated as specified in section 8.1.

7.1.2 The system drift check must be performed as specified in section 8.2.

7.2 Audits.

7.2.1 Audit Procedure. Concurrently, analyze the audit sample and a set of compliance samples in the same manner to evaluate the technique of the analyst and the standards preparation. The same analyst, analytical reagents, and analytical system shall be used both for compliance samples and the EPA audit sample. If this condition is met, auditing of subsequent compliance analyses for the same enforcement agency within 30 days is not required. An audit sample set may not be used to validate different sets of compliance samples under the jurisdiction of different enforcement agencies, unless prior arrangements are made with both enforcement agencies.

7.2.2 Audit Samples and Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B), Quality Assurance Division, Atmospheric Research and

Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

7.2.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

8. Calibration and Standardization

8.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero- and the high-range calibration gases and adjust the analyzer calibration to provide the proper responses. Inject the low- and mid-range gases and record the responses of the measurement system. The calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system.

8.2 Systems Drift Checks. After each sample, repeat the system calibration checks in section 9.2.7 before any adjustments to the FIA or measurement system are made. If the zero or calibration drift exceeds ± 3 percent of the span value, discard the result and repeat the analysis.

Alternatively, recalibrate the FIA as in section 8.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run.

8.3 Critical Orifice Calibration.

8.3.1 Each critical orifice must be calibrated at the specific operating conditions under which it will be used. Therefore, as-

semble all components of the liquid sample analysis system as shown in Figure 204A-3. A stopwatch is also required.

8.3.2 Turn on the sample oven, sample line, and water bath heaters, and allow the system to reach the proper operating temperature. Adjust the aspirator to a vacuum of 380 mm (15 in.) Hg vacuum. Measure the time required for one soap bubble to move a known distance and record barometric pressure.

8.3.3 Repeat the calibration procedure at a vacuum of 406 mm (16 in.) Hg and at 25-mm (1-in.) Hg intervals until three consecutive determinations provide the same flow rate. Calculate the critical flow rate for the orifice in ml/min at standard conditions. Record the vacuum necessary to achieve critical flow.

9. Procedure

9.1 Determination of Liquid Input Weight.

9.1.1 Weight Difference. Determine the amount of material introduced to the process as the weight difference of the feed material before and after each sampling run. In determining the total VOC containing liquid usage, account for:

- (a) The initial (beginning) VOC containing liquid mixture.
- (b) Any solvent added during the test run.
- (c) Any coating added during the test run.
- (d) Any residual VOC containing liquid mixture remaining at the end of the sample run.

9.1.1.1 Identify all points where VOC containing liquids are introduced to the process. To obtain an accurate measurement of VOC containing liquids, start with an empty fountain (if applicable). After completing the run, drain the liquid in the fountain back into the liquid drum (if possible) and weigh the drum again. Weigh the VOC containing liquids to ± 0.5 percent of the total weight (full) or ± 1.0 percent of the total weight of VOC containing liquid used during the sample run, whichever is less. If the residual liquid cannot be returned to the drum, drain the fountain into a preweighed empty drum to determine the final weight of the liquid.

9.1.1.2 If it is not possible to measure a single representative mixture, then weigh the various components separately (e.g., if solvent is added during the sampling run, weigh the solvent before it is added to the mixture). If a fresh drum of VOC containing liquid is needed during the run, then weigh both the empty drum and fresh drum.

9.1.2 Volume Measurement (Alternative). If direct weight measurements are not feasible, the tester may use volume meters or flow rate meters and density measurements to determine the weight of liquids used if it can be demonstrated that the technique produces results equivalent to the direct weight measurements. If a single representative

mixture cannot be measured, measure the components separately.

9.2 Determination of VOC Content in Input Liquids

9.2.1 Assemble the liquid VOC content analysis system as shown in Figure 204A-1.

9.2.2 Permanently identify all of the critical orifices that may be used. Calibrate each critical orifice under the expected operating conditions (i.e., sample vacuum and temperature) against a volume meter as described in section 8.3.

9.2.3 Label and tare the sample vessels (including the stoppers and caps) and the syringes.

9.2.4 Install an empty sample vessel and perform a leak test of the system. Close the carrier gas valve and atmospheric vent and evacuate the sample vessel to 250 mm (10 in.) Hg absolute or less using the aspirator. Close the toggle valve at the inlet to the aspirator and observe the vacuum for at least 1 minute. If there is any change in the sample pressure, release the vacuum, adjust or repair the apparatus as necessary, and repeat the leak test.

9.2.5 Perform the analyzer calibration and linearity checks according to the procedure in section 5.1. Record the responses to each of the calibration gases and the back-pressure setting of the FIA.

9.2.6 Establish the appropriate dilution ratio by adjusting the aspirator air supply or substituting critical orifices. Operate the aspirator at a vacuum of at least 25 mm (1 in.) Hg greater than the vacuum necessary to achieve critical flow. Select the dilution ratio so that the maximum response of the FIA to the sample does not exceed the high-range calibration gas.

9.2.7 Perform system calibration checks at two levels by introducing compressed gases at the inlet to the sample vessel while the aspirator and dilution devices are operating. Perform these checks using the carrier gas (zero concentration) and the system calibration gas. If the response to the carrier gas exceeds ± 0.5 percent of span, clean or repair the apparatus and repeat the check. Adjust the dilution ratio as necessary to achieve the correct response to the upscale check, but do not adjust the analyzer calibration. Record the identification of the orifice, aspirator air supply pressure, FIA back-pressure, and the responses of the FIA to the carrier and system calibration gases.

9.2.8 After completing the above checks, inject the system calibration gas for approximately 10 minutes. Time the exact duration of the gas injection using a stopwatch. Determine the area under the FIA response curve and calculate the system response factor based on the sample gas flow rate, gas concentration, and the duration of the injection as compared to the integrated response using Equations 204A-2 and 204A-3.

9.2.9 Verify that the sample oven and sample line temperatures are 120 ± 5 °C and that the water bath temperature is 100 ± 5 °C.

9.2.10 Fill a tared syringe with approximately 1 g of the VOC containing liquid and weigh it. Transfer the liquid to a tared sample vessel. Plug the sample vessel to minimize sample loss. Weigh the sample vessel containing the liquid to determine the amount of sample actually received. Also, as a quality control check, weigh the empty syringe to determine the amount of material delivered. The two coating sample weights should agree within 0.02 g. If not, repeat the procedure until an acceptable sample is obtained.

9.2.11 Connect the vessel to the analysis system. Adjust the aspirator supply pressure to the correct value. Open the valve on the carrier gas supply to the sample vessel and adjust it to provide a slight excess flow to the atmospheric vent. As soon as the initial response of the FIA begins to decrease, immerse the sample vessel in the water bath. (Applying heat to the sample vessel too soon may cause the FIA response to exceed the calibrated range of the instrument and, thus, invalidate the analysis.)

9.2.12 Continuously measure and record the response of the FIA until all of the volatile material has been evaporated from the sample and the instrument response has returned to the baseline (i.e., response less than 0.5 percent of the span value). Observe the aspirator supply pressure, FIA back-pressure, atmospheric vent, and other system operating parameters during the run; repeat the analysis procedure if any of these parameters deviate from the values established during the system calibration checks in section 9.2.7. After each sample, perform the drift check described in section 8.2. If the drift check results are acceptable, calculate the VOC content of the sample using the equations in section 11.2. Alternatively, recalibrate the FIA as in section 8.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. Integrate the area under the FIA response curve, or determine the average concentration response and the duration of sample analysis.

10. Data Analysis and Calculations

10.1 Nomenclature.

A_L =area under the response curve of the liquid sample, area count.

A_S =area under the response curve of the calibration gas, area count.

C_S =actual concentration of system calibration gas, ppm propane.

$K=1.830 \times 10^{-9}$ g/(ml-ppm).

L =total VOC content of liquid input, kg.

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M_L =mass of liquid sample delivered to the sample vessel, g.
 q = flow rate through critical orifice, ml/min.
 RF =liquid analysis system response factor, g/area count.
 θ_s =total gas injection time for system calibration gas during integrator calibration, min.
 V_{Fj} =final VOC fraction of VOC containing liquid j.
 V_{ij} =initial VOC fraction of VOC containing liquid j.

V_{Aj} =VOC fraction of VOC containing liquid j added during the run.
 V =VOC fraction of liquid sample.
 W_{Fj} =weight of VOC containing liquid j remaining at end of the run, kg.
 W_{ij} =weight of VOC containing liquid j at beginning of the run, kg.
 W_{Aj} =weight of VOC containing liquid j added during the run, kg.
 10.2 Calculations
 10.2.1 Total VOC Content of the Input VOC Containing Liquid.

$$L = \sum_{j=1}^n V_{ij} W_{ij} - \sum_{j=1}^n V_{Fj} W_{Fj} + \sum_{j=1}^n V_{Aj} W_{Aj} \quad \text{Eq. 204A-1}$$

10.2.2 Liquid Sample Analysis System Response Factor for Systems Using Integrators, Grams/Area Count.

$$RF = \frac{C_s q \theta_s K}{A_s} \quad \text{Eq. 204A-2}$$

10.2.3 VOC Content of the Liquid Sample.

$$V = \frac{A_L RF}{M_L} \quad \text{Eq. 204A-3}$$

11. Method Performance

The measurement uncertainties are estimated for each VOC containing liquid as follows: $W = \pm 2.0$ percent and $V = \pm 4.0$ percent. Based on these numbers, the probable uncertainty for L is estimated at about ± 4.5 percent for each VOC containing liquid.

12. Diagrams

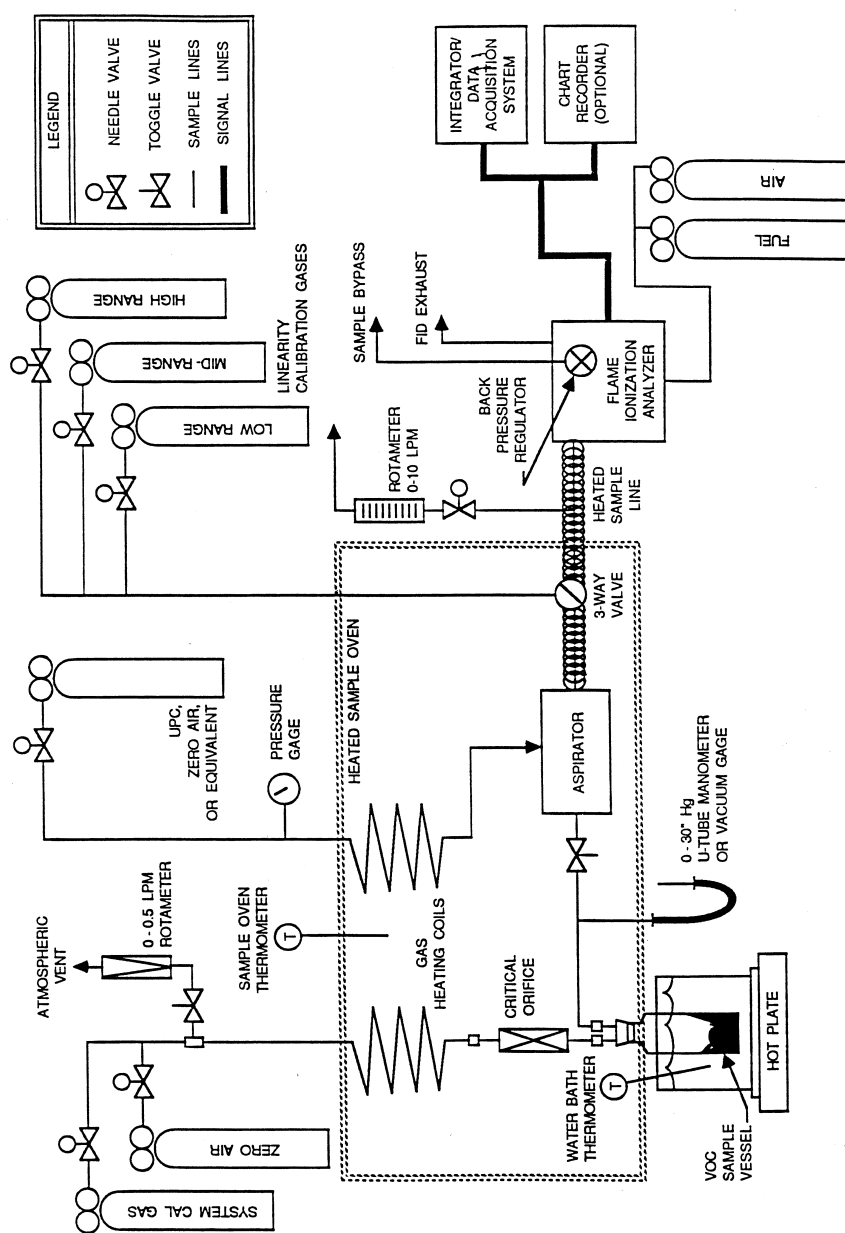


Figure 204A-1. Liquid analysis sample system.

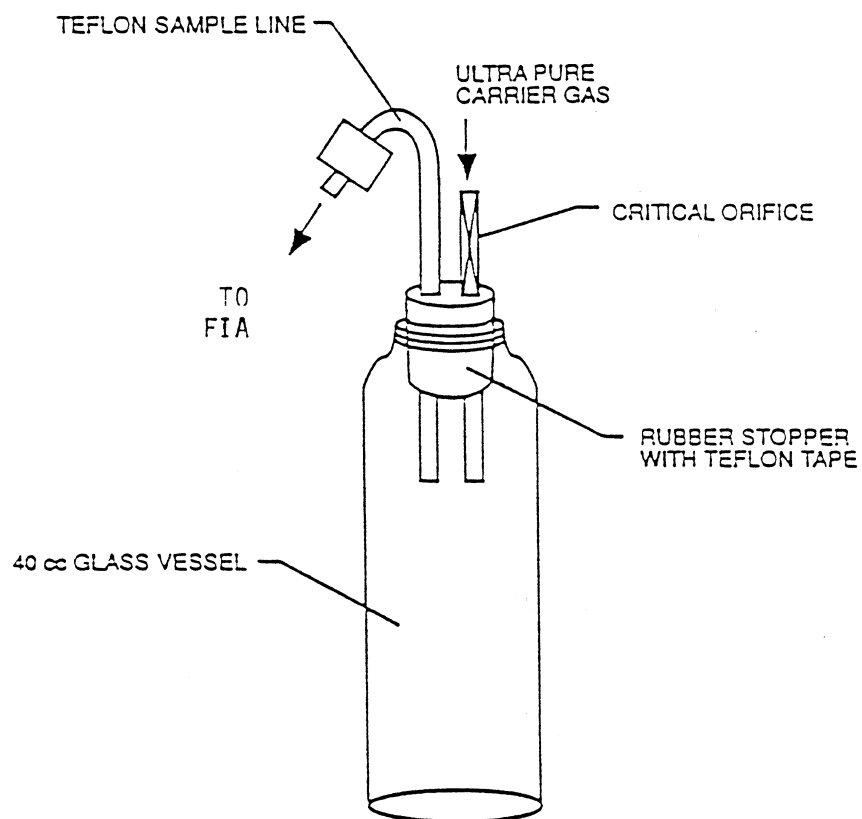


Figure 204A-2. VOC sampling vessel.

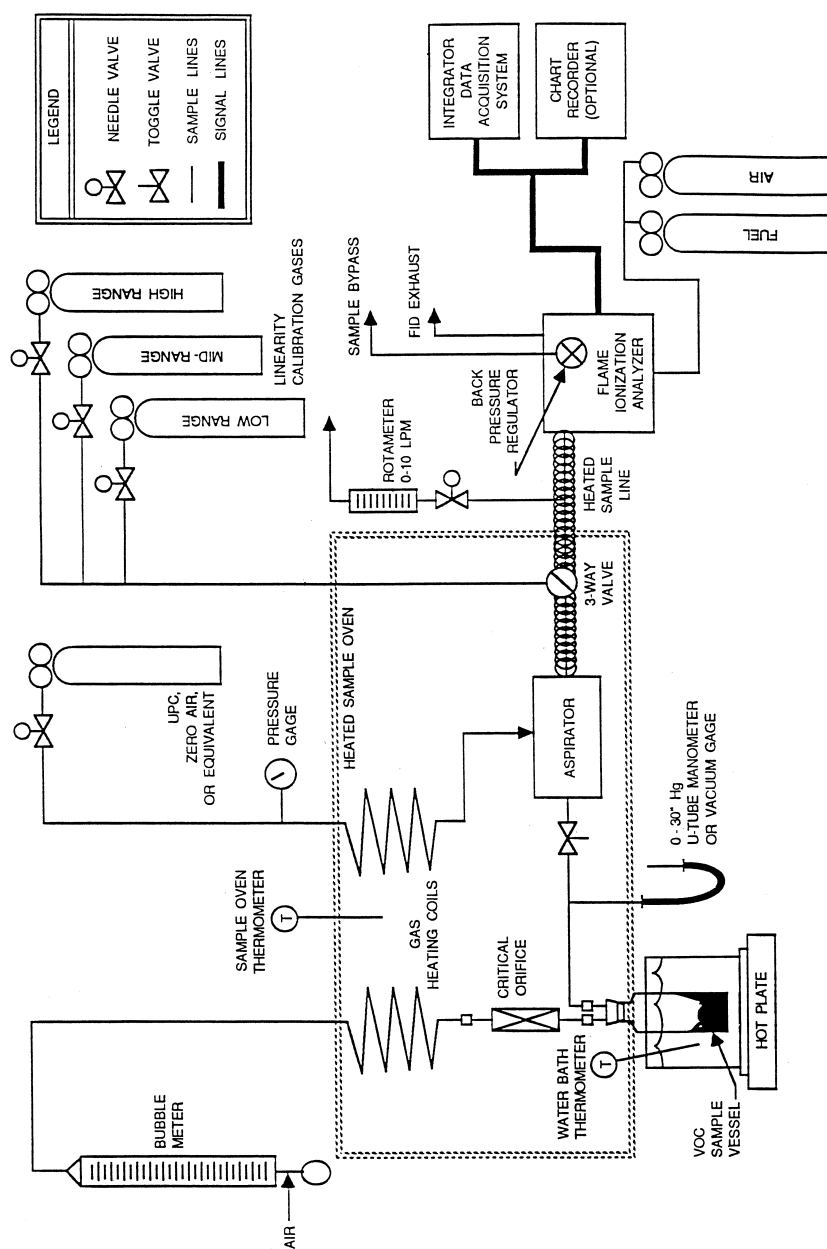


Figure 204A-3. Critical orifice calibration apparatus.

METHOD 204B—VOLATILE ORGANIC COMPOUNDS
EMISSIONS IN CAPTURED STREAM*1. Scope and Application*

1.1 Applicability. This procedure is applicable for determining the volatile organic compounds (VOC) content of captured gas streams. It is intended to be used in the development of a gas/gas protocol for determining VOC capture efficiency (CE) for surface coating and printing operations. The procedure may not be acceptable in certain site-specific situations [e.g., when: (1) direct-fired heaters or other circumstances affect the quantity of VOC at the control device inlet; and (2) particulate organic aerosols are formed in the process and are present in the captured emissions].

1.2 Principle. The amount of VOC captured (G) is calculated as the sum of the products of the VOC content (C_{Gj}), the flow rate (Q_{Gj}), and the sample time (Θ_c) from each captured emissions point.

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

A gas sample is extracted from the source through a heated sample line and, if necessary, a glass fiber filter to a flame ionization analyzer (FIA).

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Gas VOC Concentration. A schematic of the measurement system is shown in Figure 204B-1. The main components are as follows:

4.1.1 Sample Probe. Stainless steel or equivalent. The probe shall be heated to prevent VOC condensation.

4.1.2 Calibration Valve Assembly. Three-way valve assembly at the outlet of the sample probe to direct the zero and calibration gases to the analyzer. Other methods, such as quick-connect lines, to route calibration gases to the outlet of the sample probe are acceptable.

4.1.3 Sample Line. Stainless steel or Teflon tubing to transport the sample gas to the

analyzer. The sample line must be heated to prevent condensation.

4.1.4 Sample Pump. A leak-free pump, to pull the sample gas through the system at a flow rate sufficient to minimize the response time of the measurement system. The components of the pump that contact the gas stream shall be constructed of stainless steel or Teflon. The sample pump must be heated to prevent condensation.

4.1.5 Sample Flow Rate Control. A sample flow rate control valve and rotameter, or equivalent, to maintain a constant sampling rate within 10 percent. The flow rate control valve and rotameter must be heated to prevent condensation. A control valve may also be located on the sample pump bypass loop to assist in controlling the sample pressure and flow rate.

4.1.6 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated to the Administrator's satisfaction that they would provide equally accurate measurements. The system shall be capable of meeting or exceeding the following specifications:

4.1.6.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.1.6.2 Calibration Drift. Less than ± 3.0 percent of the span value.

4.1.6.3 Calibration Error. Less than ± 5.0 percent of the calibration gas value.

4.1.6.4 Response Time. Less than 30 seconds.

4.1.7 Integrator/Data Acquisition System. An analog or digital device, or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data. The minimum data sampling frequency for computing average or integrated values is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2 Captured Emissions Volumetric Flow Rate.

4.2.1 Method 2 or 2A Apparatus. For determining volumetric flow rate.

4.2.2 Method 3 Apparatus and Reagents. For determining molecular weight of the gas stream. An estimate of the molecular weight of the gas stream may be used if approved by the Administrator.

4.2.3 Method 4 Apparatus and Reagents. For determining moisture content, if necessary.

5. Reagents and Standards

5.1 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of

the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.1.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H_2 /60 percent He or 40 percent H_2 /60 percent N_2 gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.1.2 Carrier Gas. High purity air with less than 1 ppm of organic material (as propane or carbon equivalent) or less than 0.1 percent of the span value, whichever is greater.

5.1.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentrations of 20-30, 45-55, and 70-80 percent of the span value in air, respectively. Other calibration values and other span values may be used if it can be shown to the Administrator's satisfaction that equally accurate measurements would be achieved.

5.2 Particulate Filter. An in-stack or an out-of-stack glass fiber filter is recommended if exhaust gas particulate loading is significant. An out-of-stack filter must be heated to prevent any condensation unless it can be demonstrated that no condensation occurs.

6. Quality Control

6.1 Required instrument quality control parameters are found in the following sections:

6.1.1 The FIA system must be calibrated as specified in section 7.1.

6.1.2 The system drift check must be performed as specified in section 7.2.

6.1.3 The system check must be conducted as specified in section 7.3.

6.2 Audits.

6.2.1 Analysis Audit Procedure. Immediately before each test, analyze an audit cylinder as described in section 7.2. The analysis audit must agree with the audit cylinder concentration within 10 percent.

6.2.2 Audit Samples and Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Tri-

angle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.2.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calibration and Standardization

7.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero and the high-range calibration gases and adjust the analyzer calibration to provide the proper responses. Inject the low- and mid-range gases and record the responses of the measurement system. The calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system.

7.2 Systems Drift Checks. Select the calibration gas that most closely approximates the concentration of the captured emissions for conducting the drift checks. Introduce the zero and calibration gases at the calibration valve assembly and verify that the appropriate gas flow rate and pressure are present at the FIA. Record the measurement system responses to the zero and calibration gases. The performance of the system is acceptable if the difference between the drift check measurement and the value obtained in section 7.1 is less than 3 percent of the span value. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value

shall be reported as the results for the test run. Conduct the system drift checks at the end of each run.

7.3 System Check. Inject the high-range calibration gas at the inlet of the sampling probe and record the response. The performance of the system is acceptable if the measurement system response is within 5 percent of the value obtained in section 7.1 for the high-range calibration gas. Conduct a system check before and after each test run.

8. Procedure

8.1. Determination of Volumetric Flow Rate of Captured Emissions.

8.1.1 Locate all points where emissions are captured from the affected facility. Using Method 1, determine the sampling points. Be sure to check each site for cyclonic or swirling flow.

8.1.2 Measure the velocity at each sampling site at least once every hour during each sampling run using Method 2 or 2A.

8.2 Determination of VOC Content of Captured Emissions.

8.2.1 Analysis Duration. Measure the VOC responses at each captured emissions point during the entire test run or, if applicable, while the process is operating. If there are multiple captured emission locations, design a sampling system to allow a single FIA to be used to determine the VOC responses at all sampling locations.

8.2.2 Gas VOC Concentration.

8.2.2.1 Assemble the sample train as shown in Figure 204B-1. Calibrate the FIA according to the procedure in section 7.1.

8.2.2.2 Conduct a system check according to the procedure in section 7.3.

8.2.2.3 Install the sample probe so that the probe is centrally located in the stack, pipe, or duct, and is sealed tightly at the stack port connection.

8.2.2.4 Inject zero gas at the calibration valve assembly. Allow the measurement system response to reach zero. Measure the system response time as the time required for the system to reach the effluent concentration after the calibration valve has been returned to the effluent sampling position.

8.2.2.5 Conduct a system check before, and a system drift check after, each sampling run according to the procedures in sections 7.2 and 7.3. If the drift check following a run indicates unacceptable performance (see section 7.3), the run is not valid. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. The tester may elect to perform system drift checks during the run not to exceed one drift check per hour.

8.2.2.6 Verify that the sample lines, filter, and pump temperatures are 120 ± 5 °C.

8.2.2.7 Begin sampling at the start of the test period and continue to sample during the entire run. Record the starting and ending times and any required process information as appropriate. If multiple captured emission locations are sampled using a single FIA, sample at each location for the same amount of time (e.g., 2 minutes) and continue to switch from one location to another for the entire test run. Be sure that total sampling time at each location is the same at the end of the test run. Collect at least four separate measurements from each sample point during each hour of testing. Disregard the measurements at each sampling location until two times the response time of the measurement system has elapsed. Continue sampling for at least 1 minute and record the concentration measurements.

8.2.3 Background Concentration.

NOTE: Not applicable when the building is used as the temporary total enclosure (TTE).

8.2.3.1 Locate all natural draft openings (NDO's) of the TTE. A sampling point shall be at the center of each NDO, unless otherwise specified by the Administrator. If there are more than six NDO's, choose six sampling points evenly spaced among the NDO's.

8.2.3.2 Assemble the sample train as shown in Figure 204B-2. Calibrate the FIA and conduct a system check according to the procedures in sections 7.1 and 7.3.

NOTE: This sample train shall be separate from the sample train used to measure the captured emissions.

8.2.3.3 Position the probe at the sampling location.

8.2.3.4 Determine the response time, conduct the system check, and sample according to the procedures described in sections 8.2.2.4 through 8.2.2.7.

8.2.4 Alternative Procedure. The direct interface sampling and analysis procedure described in section 7.2 of Method 18 may be used to determine the gas VOC concentration. The system must be designed to collect and analyze at least one sample every 10 minutes. If the alternative procedure is used to determine the VOC concentration of the captured emissions, it must also be used to determine the VOC concentration of the uncaptured emissions.

9. Data Analysis and Calculations

9.1 Nomenclature.

A_i =area of NDO i , ft².

A_N =total area of all NDO's in the enclosure, ft².

C_{Bi} =corrected average VOC concentration of background emissions at point i , ppm propane.

C_B =average background concentration, ppm propane.

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C_{Gj} =corrected average VOC concentration of captured emissions at point j, ppm propane.

C_{DH} =average measured concentration for the drift check calibration gas, ppm propane.

C_{DO} =average system drift check concentration for zero concentration gas, ppm propane.

C_H =actual concentration of the drift check calibration gas, ppm propane.

C_i =uncorrected average background VOC concentration measured at point i, ppm propane.

C_j =uncorrected average VOC concentration measured at point j, ppm propane.

G =total VOC content of captured emissions, kg.

$K_1=1.830 \times 10^{-6}$ kg/(m³-ppm).

n =number of measurement points.

Q_{Gj} =average effluent volumetric flow rate corrected to standard conditions at captured emissions point j, m³/min.

Θ_c =total duration of captured emissions.

9.2 Calculations.

9.2.1 Total VOC Captured Emissions.

$$G = \sum_{j=1}^n (C_{Gj} - C_B) Q_{Gj} \theta_c K_1 \quad \text{Eq. 204B-1}$$

9.2.2 VOC Concentration of the Captured Emissions at Point j.

$$C_{Gj} = (C_j - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204B-2}$$

9.2.3 Background VOC Concentration at Point i.

$$C_{Bi} = (C_i - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204B-3}$$

9.2.4 Average Background Concentration.

$$C_B = \frac{\sum_{i=1}^n C_{Bi} A_i}{A_N} \quad \text{Eq. 204B-4}$$

NOTE: If the concentration at each point is within 20 percent of the average concentration of all points, then use the arithmetic average.

10. Method Performance

The measurement uncertainties are estimated for each captured or uncaptured emissions point as follows: $Q_{Gj}=\pm 5.5$ percent and $C_{Gj}=\pm 5.0$ percent. Based on these numbers, the probable uncertainty for G is estimated at about ± 7.4 percent.

11. Diagrams

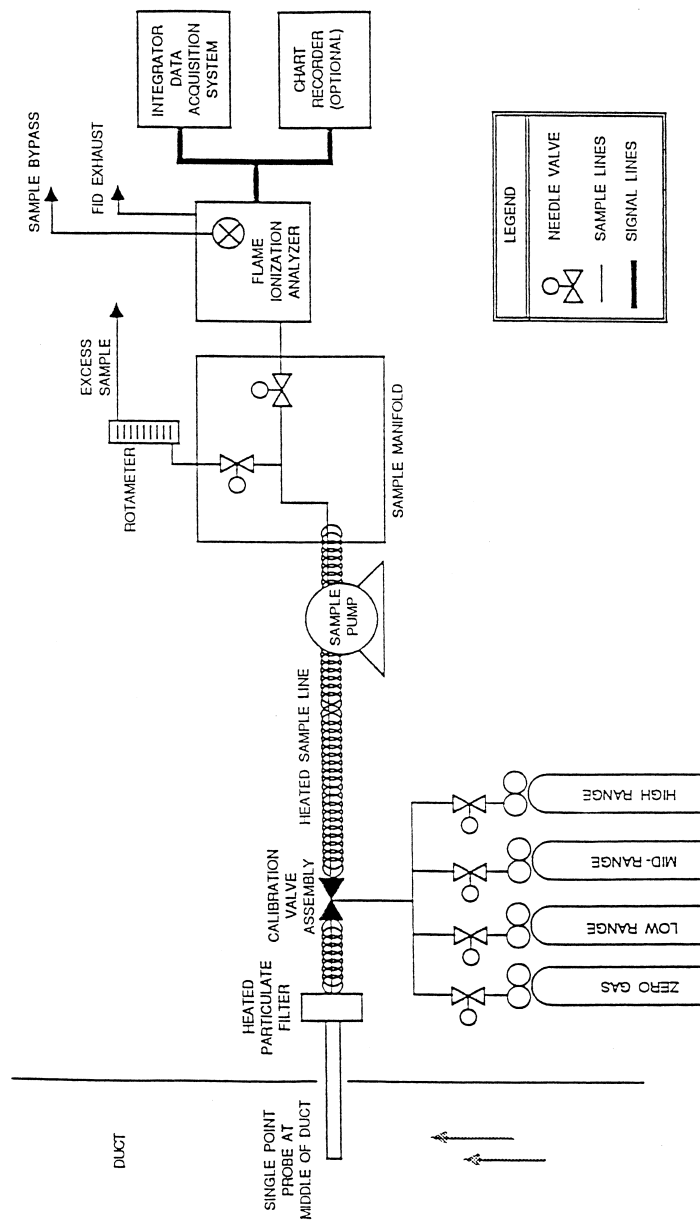


Figure 204B-1. Gas VOC concentration measurement system.

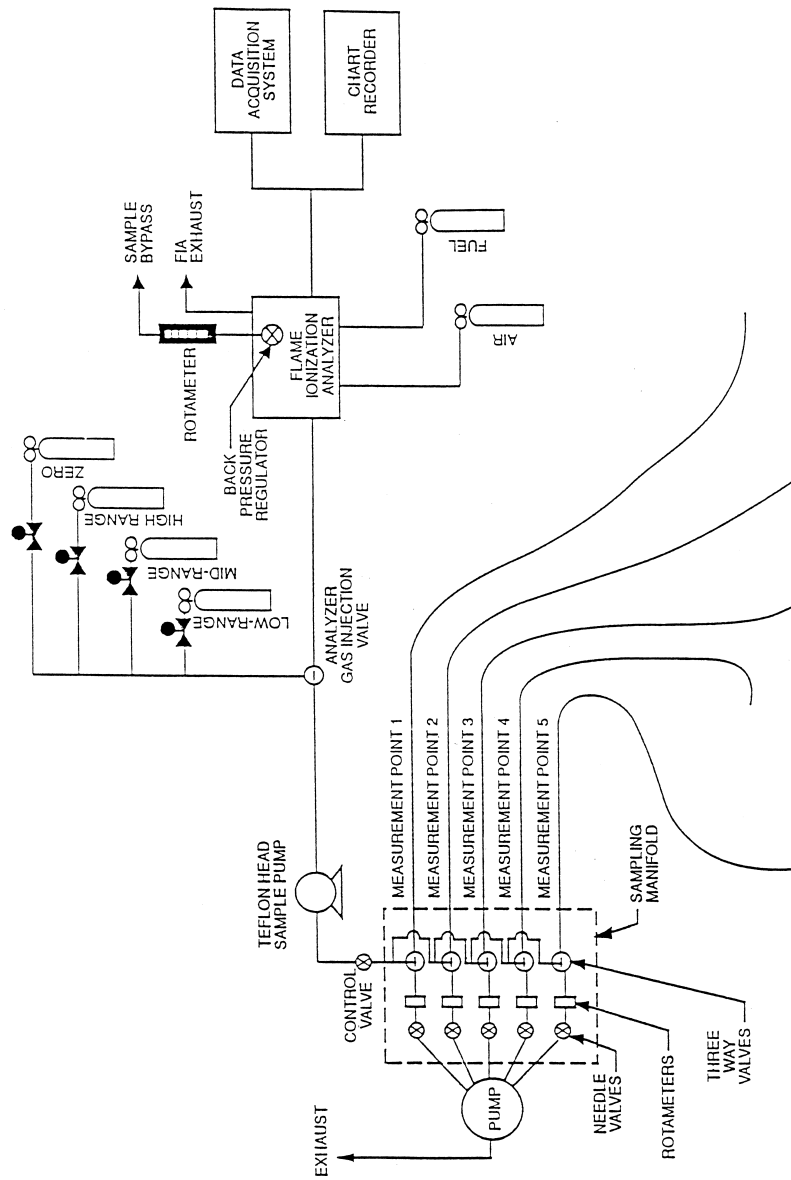


Figure 204B-2. Background measurement system.

METHOD 204C—VOLATILE ORGANIC COMPOUNDS
EMISSIONS IN CAPTURED STREAM (DILUTION
TECHNIQUE)*1. Scope and Application*

1.1 **Applicability.** This procedure is applicable for determining the volatile organic compounds (VOC) content of captured gas streams. It is intended to be used in the development of a gas/gas protocol in which uncaptured emissions are also measured for determining VOC capture efficiency (CE) for surface coating and printing operations. A dilution system is used to reduce the VOC concentration of the captured emissions to about the same concentration as the uncaptured emissions. The procedure may not be acceptable in certain site-specific situations [e.g., when: (1) direct-fired heaters or other circumstances affect the quantity of VOC at the control device inlet; and (2) particulate organic aerosols are formed in the process and are present in the captured emissions].

1.2 **Principle.** The amount of VOC captured (G) is calculated as the sum of the products of the VOC content (C_{Gi}), the flow rate (Q_{Gi}), and the sampling time (Θ_c) from each captured emissions point.

1.3 **Sampling Requirements.** A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

A gas sample is extracted from the source using an in-stack dilution probe through a heated sample line and, if necessary, a glass fiber filter to a flame ionization analyzer (FIA). The sample train contains a sample gas manifold which allows multiple points to be sampled using a single FIA.

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 **Gas VOC Concentration.** A schematic of the measurement system is shown in Figure 204C-1. The main components are as follows:

4.1.1 **Dilution System.** A Kipp in-stack dilution probe and controller or similar device may be used. The dilution rate may be

changed by substituting different critical orifices or adjustments of the aspirator supply pressure. The dilution system shall be heated to prevent VOC condensation. Note: An out-of-stack dilution device may be used.

4.1.2 **Calibration Valve Assembly.** Three-way valve assembly at the outlet of the sample probe to direct the zero and calibration gases to the analyzer. Other methods, such as quick-connect lines, to route calibration gases to the outlet of the sample probe are acceptable.

4.1.3 **Sample Line.** Stainless steel or Teflon tubing to transport the sample gas to the analyzer. The sample line must be heated to prevent condensation.

4.1.4 **Sample Pump.** A leak-free pump, to pull the sample gas through the system at a flow rate sufficient to minimize the response time of the measurement system. The components of the pump that contact the gas stream shall be constructed of stainless steel or Teflon. The sample pump must be heated to prevent condensation.

4.1.5 **Sample Flow Rate Control.** A sample flow rate control valve and rotameter, or equivalent, to maintain a constant sampling rate within 10 percent. The flow control valve and rotameter must be heated to prevent condensation. A control valve may also be located on the sample pump bypass loop to assist in controlling the sample pressure and flow rate.

4.1.6 **Sample Gas Manifold.** Capable of diverting a portion of the sample gas stream to the FIA, and the remainder to the bypass discharge vent. The manifold components shall be constructed of stainless steel or Teflon. If captured or uncaptured emissions are to be measured at multiple locations, the measurement system shall be designed to use separate sampling probes, lines, and pumps for each measurement location and a common sample gas manifold and FIA. The sample gas manifold and connecting lines to the FIA must be heated to prevent condensation.

NOTE: Depending on the number of sampling points and their location, it may not be possible to use only one FIA. However to reduce the effect of calibration error, the number of FIA's used during a test should be kept as small as possible.

4.1.7 **Organic Concentration Analyzer.** An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated to the Administrator's satisfaction that they would provide equally accurate measurements. The system shall be capable of meeting or exceeding the following specifications:

4.1.7.1 **Zero Drift.** Less than ± 3.0 percent of the span value.

4.1.7.2 **Calibration Drift.** Less than ± 3.0 percent of the span value.

4.1.7.3 Calibration Error. Less than ± 5.0 percent of the calibration gas value.

4.1.7.4 Response Time. Less than 30 seconds.

4.1.8 Integrator/Data Acquisition System. An analog or digital device or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data. The minimum data sampling frequency for computing average or integrated values is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2 Captured Emissions Volumetric Flow Rate.

4.2.1 Method 2 or 2A Apparatus. For determining volumetric flow rate.

4.2.2 Method 3 Apparatus and Reagents. For determining molecular weight of the gas stream. An estimate of the molecular weight of the gas stream may be used if approved by the Administrator.

4.2.3 Method 4 Apparatus and Reagents. For determining moisture content, if necessary.

5. Reagents and Standards

5.1 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.1.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H_2 /60 percent He or 40 percent H_2 /60 percent N_2 gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.1.2 Carrier Gas and Dilution Air Supply. High purity air with less than 1 ppm of organic material (as propane or carbon equivalent), or less than 0.1 percent of the span value, whichever is greater.

5.1.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentrations of 20–30, 45–55, and 70–80 percent of the span value in air, respectively. Other calibration values and other span values may be

used if it can be shown to the Administrator's satisfaction that equally accurate measurements would be achieved.

5.1.4 Dilution Check Gas. Gas mixture standard containing propane in air, approximately half the span value after dilution.

5.2 Particulate Filter. An in-stack or an out-of-stack glass fiber filter is recommended if exhaust gas particulate loading is significant. An out-of-stack filter must be heated to prevent any condensation unless it can be demonstrated that no condensation occurs.

6. Quality Control

6.1 Required instrument quality control parameters are found in the following sections:

6.1.1 The FIA system must be calibrated as specified in section 7.1.

6.1.2 The system drift check must be performed as specified in section 7.2.

6.1.3 The dilution factor must be determined as specified in section 7.3.

6.1.4 The system check must be conducted as specified in section 7.4.

6.2 Audits.

6.2.1 Analysis Audit Procedure. Immediately before each test, analyze an audit cylinder as described in section 7.2. The analysis audit must agree with the audit cylinder concentration within 10 percent.

6.2.2 Audit Samples and Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.2.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calibration and Standardization

7.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system after the dilution system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero- and the high-range calibration gases and adjust the analyzer calibration to provide the proper responses. Inject the low- and mid-range gases and record the responses of the measurement system. The calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system.

7.2 Systems Drift Checks. Select the calibration gas that most closely approximates the concentration of the diluted captured emissions for conducting the drift checks. Introduce the zero and calibration gases at the calibration valve assembly, and verify that the appropriate gas flow rate and pressure are present at the FIA. Record the measurement system responses to the zero and calibration gases. The performance of the system is acceptable if the difference between the drift check measurement and the value obtained in section 7.1 is less than 3 percent of the span value. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. Conduct the system drift check at the end of each run.

7.3 Determination of Dilution Factor. Inject the dilution check gas into the measurement system before the dilution system and record the response. Calculate the dilution factor using Equation 204C-3.

7.4 System Check. Inject the high-range calibration gas at the inlet to the sampling probe while the dilution air is turned off. Record the response. The performance of the system is acceptable if the measurement system response is within 5 percent of the value obtained in section 7.1 for the high-range calibration gas. Conduct a system check before and after each test run.

8. Procedure

8.1 Determination of Volumetric Flow Rate of Captured Emissions

8.1.1 Locate all points where emissions are captured from the affected facility.

Using Method 1, determine the sampling points. Be sure to check each site for cyclonic or swirling flow.

8.2.2 Measure the velocity at each sampling site at least once every hour during each sampling run using Method 2 or 2A.

8.2 Determination of VOC Content of Captured Emissions

8.2.1 Analysis Duration. Measure the VOC responses at each captured emissions point during the entire test run or, if applicable, while the process is operating. If there are multiple captured emissions locations, design a sampling system to allow a single FIA to be used to determine the VOC responses at all sampling locations.

8.2.2 Gas VOC Concentration.

8.2.2.1 Assemble the sample train as shown in Figure 204C-1. Calibrate the FIA according to the procedure in section 7.1.

8.2.2.2 Set the dilution ratio and determine the dilution factor according to the procedure in section 7.3.

8.2.2.3 Conduct a system check according to the procedure in section 7.4.

8.2.2.4 Install the sample probe so that the probe is centrally located in the stack, pipe, or duct, and is sealed tightly at the stack port connection.

8.2.2.5 Inject zero gas at the calibration valve assembly. Measure the system response time as the time required for the system to reach the effluent concentration after the calibration valve has been returned to the effluent sampling position.

8.2.2.6 Conduct a system check before, and a system drift check after, each sampling run according to the procedures in sections 7.2 and 7.4. If the drift check following a run indicates unacceptable performance (see section 7.4), the run is not valid. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. The tester may elect to perform system drift checks during the run not to exceed one drift check per hour.

8.2.2.7 Verify that the sample lines, filter, and pump temperatures are 120 ± 5 °C.

8.2.2.8 Begin sampling at the start of the test period and continue to sample during the entire run. Record the starting and ending times and any required process information as appropriate. If multiple captured emission locations are sampled using a single FIA, sample at each location for the same amount of time (e.g., 2 min.) and continue to switch from one location to another for the entire test run. Be sure that total sampling time at each location is the same at the end of the test run. Collect at least four separate measurements from each sample point during each hour of testing. Disregard the measurements at each sampling

location until two times the response time of the measurement system has elapsed. Continue sampling for at least 1 minute and record the concentration measurements.

8.2.3 Background Concentration.

NOTE: Not applicable when the building is used as the temporary total enclosure (TTE).

8.2.3.1 Locate all natural draft openings (NDO's) of the TTE. A sampling point shall be at the center of each NDO, unless otherwise approved by the Administrator. If there are more than six NDO's, choose six sampling points evenly spaced among the NDO's.

8.2.3.2 Assemble the sample train as shown in Figure 204C-2. Calibrate the FIA and conduct a system check according to the procedures in sections 7.1 and 7.4.

8.2.3.3 Position the probe at the sampling location.

8.2.3.4 Determine the response time, conduct the system check, and sample according to the procedures described in sections 8.2.2.4 through 8.2.2.8.

8.2.4 Alternative Procedure. The direct interface sampling and analysis procedure described in section 7.2 of Method 18 may be used to determine the gas VOC concentration. The system must be designed to collect and analyze at least one sample every 10 minutes. If the alternative procedure is used to determine the VOC concentration of the captured emissions, it must also be used to determine the VOC concentration of the uncaptured emissions.

9. Data Analysis and Calculations

9.1 Nomenclature.

A_i =area of NDO i , ft².

A_N =total area of all NDO's in the enclosure, ft².

C_A = actual concentration of the dilution check gas, ppm propane.

C_{Bi} =corrected average VOC concentration of background emissions at point i , ppm propane.

C_B =average background concentration, ppm propane.

C_{DH} =average measured concentration for the drift check calibration gas, ppm propane.

C_{Do} =average system drift check concentration for zero concentration gas, ppm propane.

C_H =actual concentration of the drift check calibration gas, ppm propane.

C_i =uncorrected average background VOC concentration measured at point i , ppm propane.

C_j =uncorrected average VOC concentration measured at point j , ppm propane.

C_M =measured concentration of the dilution check gas, ppm propane.

DF=dilution factor.

G =total VOC content of captured emissions, kg.

K_1 = 1.830×10^{-6} kg/(m³-ppm).

n =number of measurement points.

Q_{Gj} =average effluent volumetric flow rate corrected to standard conditions at captured emissions point j , m³/min.

Θ_C =total duration of CE sampling run, min.

9.2 Calculations.

9.2.1 Total VOC Captured Emissions.

$$G = \sum_{j=1}^n (C_{Gj} - C_B) Q_{Gj} \Theta_C K_1 \quad \text{Eq. 204C-1}$$

9.2.2 VOC Concentration of the Captured Emissions at Point j .

$$C_{Gj} = DF (C_j - C_{Do}) \frac{C_H}{C_{DH} - C_{Do}} \quad \text{Eq. 204C-2}$$

9.2.3 Dilution Factor.

$$DF = \frac{C_A}{C_M} \quad \text{Eq. 204C-3}$$

9.2.4 Background VOC Concentration at Point i .

$$C_{Bi} = (C_i - C_{Do}) \frac{C_H}{C_{DH} - C_{Do}} \quad \text{Eq. 204C-4}$$

9.2.5 Average Background Concentration.

$$C_B = \frac{\sum_{i=1}^n C_{Bi} A_i}{A_N} \quad \text{Eq. 204C-5}$$

NOTE: If the concentration at each point is within 20 percent of the average concentration of all points, then use the arithmetic average.

10. Method Performance

The measurement uncertainties are estimated for each captured or uncaptured emissions point as follows: Q_{Gj} = ± 5.5 percent and C_{Gj} = ± 5 percent. Based on these numbers, the probable uncertainty for G is estimated at about ± 7.4 percent.

11. Diagrams

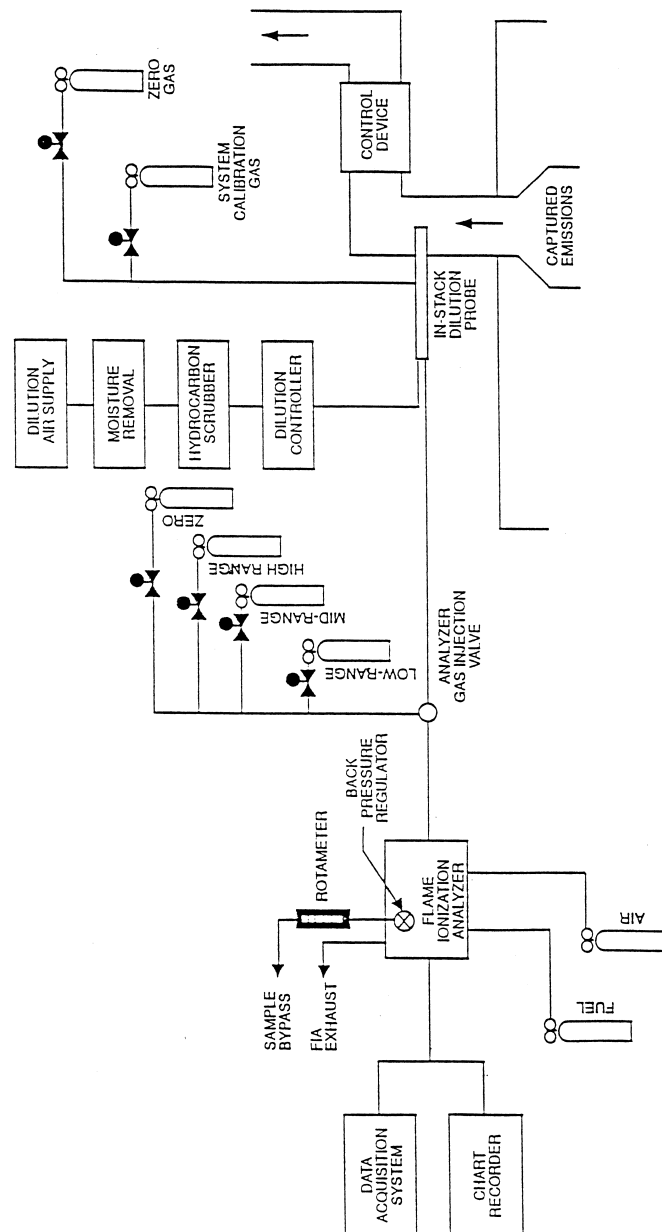


Figure 204C-1. Captured emissions measurement system.

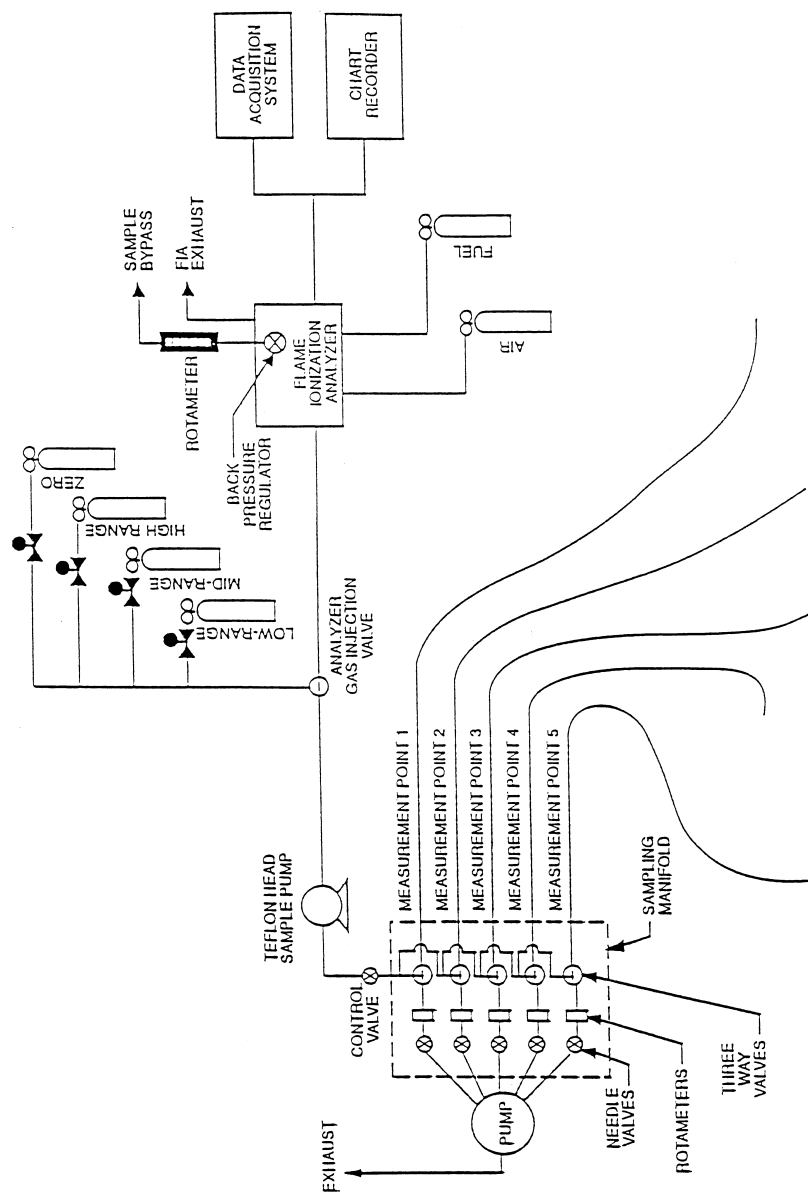


Figure 204C-2. Background measurement system.

METHOD 204D—VOLATILE ORGANIC COMPOUNDS EMISSIONS IN UNCAPTURED STREAM FROM TEMPORARY TOTAL ENCLOSURE

1. Scope and Application

1.1 Applicability. This procedure is applicable for determining the uncaptured vola-

tile organic compounds (VOC) emissions from a temporary total enclosure (TTE). It is intended to be used as a segment in the development of liquid/gas or gas/gas protocols for determining VOC capture efficiency (CE) for surface coating and printing operations.

1.2 Principle. The amount of uncaptured VOC emissions (F) from the TTE is calculated as the sum of the products of the VOC content (C_{Fij}), the flow rate (Q_{Fij}) from each uncaptured emissions point, and the sampling time (Θ_F).

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

A gas sample is extracted from the uncaptured exhaust duct of a TTE through a heated sample line and, if necessary, a glass fiber filter to a flame ionization analyzer (FIA).

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Gas VOC Concentration. A schematic of the measurement system is shown in Figure 204D-1. The main components are as follows:

4.1.1 Sample Probe. Stainless steel or equivalent. The probe shall be heated to prevent VOC condensation.

4.1.2 Calibration Valve Assembly. Three-way valve assembly at the outlet of the sample probe to direct the zero and calibration gases to the analyzer. Other methods, such as quick-connect lines, to route calibration gases to the outlet of the sample probe are acceptable.

4.1.3 Sample Line. Stainless steel or Teflon tubing to transport the sample gas to the analyzer. The sample line must be heated to prevent condensation.

4.1.4 Sample Pump. A leak-free pump, to pull the sample gas through the system at a flow rate sufficient to minimize the response time of the measurement system. The components of the pump that contact the gas stream shall be constructed of stainless steel or Teflon. The sample pump must be heated to prevent condensation.

4.1.5 Sample Flow Rate Control. A sample flow rate control valve and rotameter, or equivalent, to maintain a constant sampling rate within 10 percent. The flow control valve and rotameter must be heated to prevent condensation. A control valve may also

be located on the sample pump bypass loop to assist in controlling the sample pressure and flow rate.

4.1.6 Sample Gas Manifold. Capable of diverting a portion of the sample gas stream to the FIA, and the remainder to the bypass discharge vent. The manifold components shall be constructed of stainless steel or Teflon. If emissions are to be measured at multiple locations, the measurement system shall be designed to use separate sampling probes, lines, and pumps for each measurement location and a common sample gas manifold and FIA. The sample gas manifold and connecting lines to the FIA must be heated to prevent condensation.

4.1.7 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated to the Administrator's satisfaction that they would provide more accurate measurements. The system shall be capable of meeting or exceeding the following specifications:

4.1.7.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.1.7.2 Calibration Drift. Less than ± 3.0 percent of the span value.

4.1.7.3 Calibration Error. Less than ± 5.0 percent of the calibration gas value.

4.1.7.4 Response Time. Less than 30 seconds.

4.1.8 Integrator/Data Acquisition System. An analog or digital device or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data. The minimum data sampling frequency for computing average or integrated values is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2 Uncaptured Emissions Volumetric Flow Rate.

4.2.1 Method 2 or 2A Apparatus. For determining volumetric flow rate.

4.2.2 Method 3 Apparatus and Reagents. For determining molecular weight of the gas stream. An estimate of the molecular weight of the gas stream may be used if approved by the Administrator.

4.2.3 Method 4 Apparatus and Reagents. For determining moisture content, if necessary.

4.3 Temporary Total Enclosure. The criteria for designing an acceptable TTE are specified in Method 204.

5. Reagents and Standards

5.1 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of

the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.1.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H_2 /60 percent He or 40 percent H_2 /60 percent N_2 gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.1.2 Carrier Gas. High purity air with less than 1 ppm of organic material (as propane or carbon equivalent) or less than 0.1 percent of the span value, whichever is greater.

5.1.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentrations of 20-30, 45-55, and 70-80 percent of the span value in air, respectively. Other calibration values and other span values may be used if it can be shown to the Administrator's satisfaction that equally accurate measurements would be achieved.

5.2 Particulate Filter. An in-stack or an out-of-stack glass fiber filter is recommended if exhaust gas particulate loading is significant. An out-of-stack filter must be heated to prevent any condensation unless it can be demonstrated that no condensation occurs.

6. Quality Control

6.1 Required instrument quality control parameters are found in the following sections:

6.1.1 The FIA system must be calibrated as specified in section 7.1.

6.1.2 The system drift check must be performed as specified in section 7.2.

6.1.3 The system check must be conducted as specified in section 7.3.

6.2 Audits.

6.2.1 Analysis Audit Procedure. Immediately before each test, analyze an audit cylinder as described in section 7.2. The analysis audit must agree with the audit cylinder concentration within 10 percent.

6.2.2 Audit Samples and Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B) Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Tri-

angle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.2.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calibration and Standardization

7.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero and the high-range calibration gases and adjust the analyzer calibration to provide the proper responses. Inject the low- and mid-range gases and record the responses of the measurement system. The calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system.

7.2 Systems Drift Checks. Select the calibration gas concentration that most closely approximates that of the uncaptured gas emissions concentration to conduct the drift checks. Introduce the zero and calibration gases at the calibration valve assembly and verify that the appropriate gas flow rate and pressure are present at the FIA. Record the measurement system responses to the zero and calibration gases. The performance of the system is acceptable if the difference between the drift check measurement and the value obtained in section 7.1 is less than 3 percent of the span value. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the

lowest CE value shall be reported as the results for the test run. Conduct a system drift check at the end of each run.

7.3 System Check. Inject the high-range calibration gas at the inlet of the sampling probe and record the response. The performance of the system is acceptable if the measurement system response is within 5 percent of the value obtained in section 7.1 for the high-range calibration gas. Conduct a system check before each test run.

8. Procedure

8.1 Determination of Volumetric Flow Rate of Uncaptured Emissions

8.1.1 Locate all points where uncaptured emissions are exhausted from the TTE. Using Method 1, determine the sampling points. Be sure to check each site for cyclonic or swirling flow.

8.1.2 Measure the velocity at each sampling site at least once every hour during each sampling run using Method 2 or 2A.

8.2 Determination of VOC Content of Uncaptured Emissions.

8.2.1 Analysis Duration. Measure the VOC responses at each uncaptured emission point during the entire test run or, if applicable, while the process is operating. If there are multiple emission locations, design a sampling system to allow a single FIA to be used to determine the VOC responses at all sampling locations.

8.2.2 Gas VOC Concentration.

8.2.2.1 Assemble the sample train as shown in Figure 204D-1. Calibrate the FIA and conduct a system check according to the procedures in sections 7.1 and 7.3, respectively.

8.2.2.2 Install the sample probe so that the probe is centrally located in the stack, pipe, or duct, and is sealed tightly at the stack port connection.

8.2.2.3 Inject zero gas at the calibration valve assembly. Allow the measurement system response to reach zero. Measure the system response time as the time required for the system to reach the effluent concentration after the calibration valve has been returned to the effluent sampling position.

8.2.2.4 Conduct a system check before, and a system drift check after, each sampling run according to the procedures in sections 7.2 and 7.3. If the drift check following a run indicates unacceptable performance (see section 7.3), the run is not valid. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. The tester may elect to perform system drift checks during the run not to exceed one drift check per hour.

8.2.2.5 Verify that the sample lines, filter, and pump temperatures are 120 ± 5 °C.

8.2.2.6 Begin sampling at the start of the test period and continue to sample during the entire run. Record the starting and ending times and any required process information, as appropriate. If multiple emission locations are sampled using a single FIA, sample at each location for the same amount of time (e.g., 2 min.) and continue to switch from one location to another for the entire test run. Be sure that total sampling time at each location is the same at the end of the test run. Collect at least four separate measurements from each sample point during each hour of testing. Disregard the response measurements at each sampling location until 2 times the response time of the measurement system has elapsed. Continue sampling for at least 1 minute and record the concentration measurements.

8.2.3 Background Concentration.

8.2.3.1 Locate all natural draft openings (NDO's) of the TTE. A sampling point shall be at the center of each NDO, unless otherwise approved by the Administrator. If there are more than six NDO's, choose six sampling points evenly spaced among the NDO's.

8.2.3.2 Assemble the sample train as shown in Figure 204D-2. Calibrate the FIA and conduct a system check according to the procedures in sections 7.1 and 7.3.

8.2.3.3 Position the probe at the sampling location.

8.2.3.4 Determine the response time, conduct the system check, and sample according to the procedures described in sections 8.2.2.3 through 8.2.2.6.

8.2.4 Alternative Procedure. The direct interface sampling and analysis procedure described in section 7.2 of Method 18 may be used to determine the gas VOC concentration. The system must be designed to collect and analyze at least one sample every 10 minutes. If the alternative procedure is used to determine the VOC concentration of the uncaptured emissions in a gas/gas protocol, it must also be used to determine the VOC concentration of the captured emissions. If a tester wishes to conduct a liquid/gas protocol using a gas chromatograph, the tester must use Method 204F for the liquid stream. A gas chromatograph is not an acceptable alternative to the FIA in Method 204A.

9. Data Analysis and Calculations

9.1 Nomenclature.

A_i =area of NDO i, ft².

A_N =total area of all NDO's in the enclosure, ft².

C_{Bi} =corrected average VOC concentration of background emissions at point i, ppm propane.

C_B =average background concentration, ppm propane.

C_{DH} =average measured concentration for the drift check calibration gas, ppm propane.

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C_{DO} =average system drift check concentration for zero concentration gas, ppm propane.

C_{Fj} =corrected average VOC concentration of uncaptured emissions at point j, ppm propane.

C_H =actual concentration of the drift check calibration gas, ppm propane.

C_i =uncorrected average background VOC concentration at point i, ppm propane.

C_j =uncorrected average VOC concentration measured at point j, ppm propane.

F =total VOC content of uncaptured emissions, kg.

$K_1=1.830 \times 10^{-6}$ kg/(m³-ppm).

n =number of measurement points.

Q_{Fj} =average effluent volumetric flow rate corrected to standard conditions at uncaptured emissions point j, m³/min.

Θ_F =total duration of uncaptured emissions sampling run, min.

9.2 Calculations.

9.2.1 Total Uncaptured VOC Emissions.

$$F = \sum_{j=1}^n (C_{Fj} - C_B) Q_{Fj} \Theta_F K_1 \quad \text{Eq. 204D-1}$$

9.2.2 VOC Concentration of the Uncaptured Emissions at Point j.

$$C_{Fj} = (C_j - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204D-2}$$

9.2.3 Background VOC Concentration at Point i.

$$C_{Bi} = (C_i - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204D-3}$$

9.2.4 Average Background Concentration.

$$C_B = \frac{\sum_{i=1}^n C_{Bi} A_i}{A_N} \quad \text{Eq. 204D-4}$$

NOTE: If the concentration at each point is within 20 percent of the average concentration of all points, use the arithmetic average.

10. Method Performance

The measurement uncertainties are estimated for each uncaptured emission point as follows: $Q_{Fj} = \pm 5.5$ percent and $C_{Fj} = \pm 5.0$ percent. Based on these numbers, the probable uncertainty for F is estimated at about ± 7.4 percent.

11. Diagrams

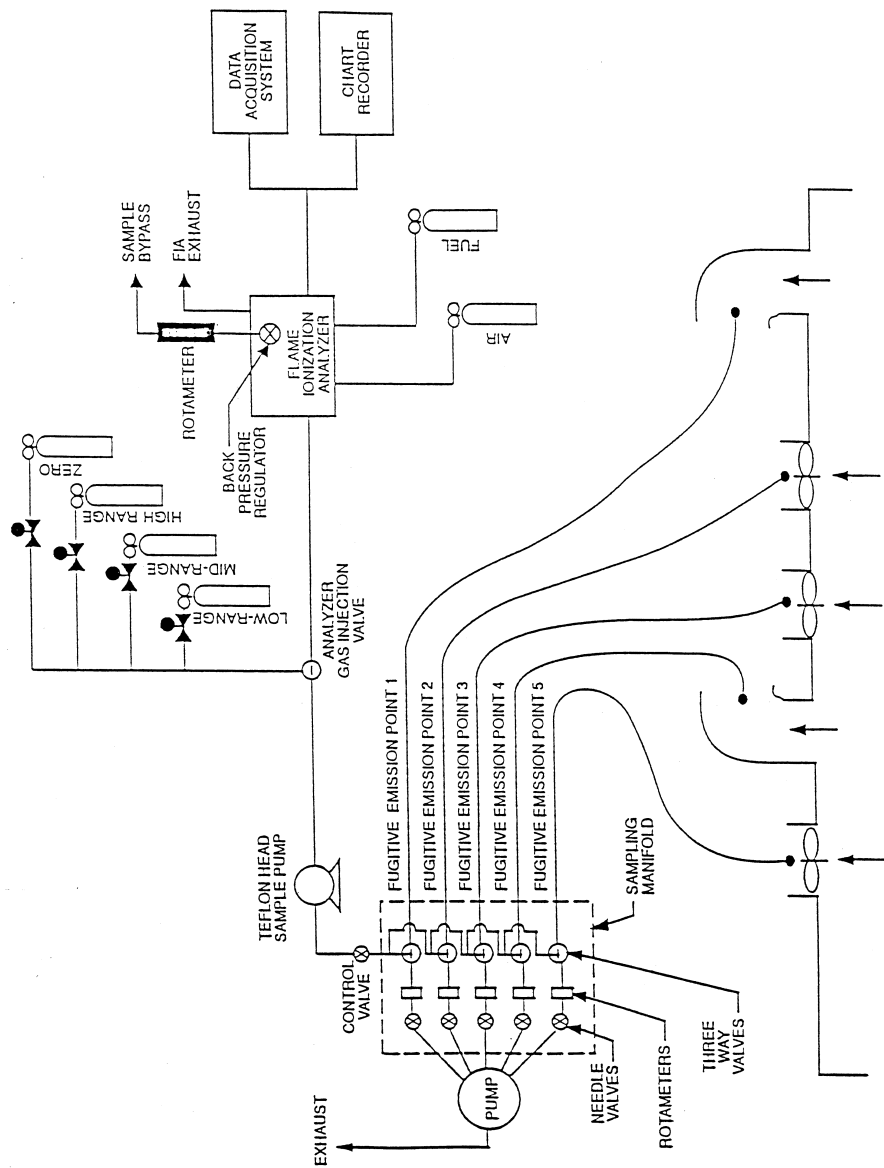


Figure 2040-1. Fugitive emissions measurement system.

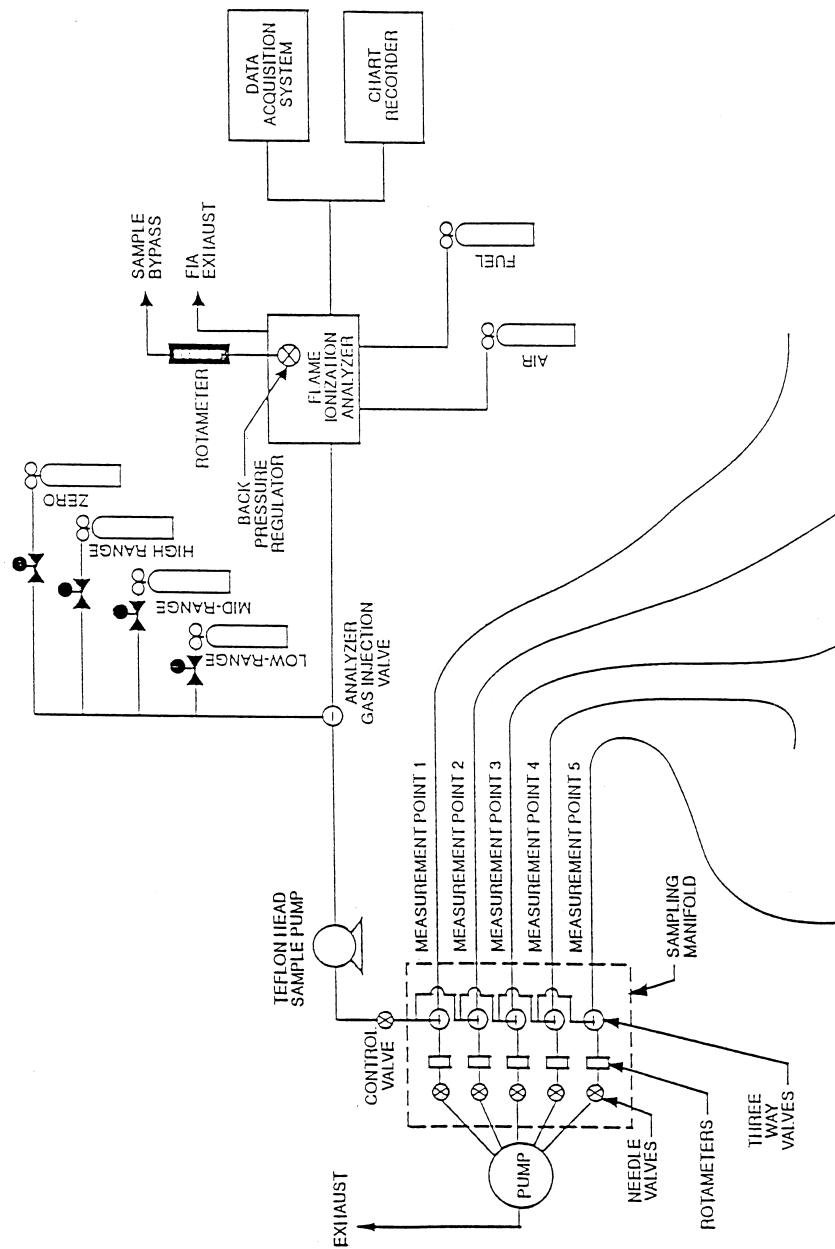


Figure 204D-2. Background measurement system.

METHOD 204E—VOLATILE ORGANIC COMPOUNDS
EMISSIONS IN UNCAPTURED STREAM FROM
BUILDING ENCLOSURE*1. Scope and Application*

1.1 Applicability. This procedure is applicable for determining the uncaptured volatile organic compounds (VOC) emissions from a building enclosure (BE). It is intended to be used in the development of liquid/gas or gas/gas protocols for determining VOC capture efficiency (CE) for surface coating and printing operations.

1.2 Principle. The total amount of uncaptured VOC emissions (F_B) from the BE is calculated as the sum of the products of the VOC content (C_{Fi}) of each uncaptured emissions point, the flow rate (Q_{Fi}) at each uncaptured emissions point, and time (Θ_F).

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

A gas sample is extracted from the uncaptured exhaust duct of a BE through a heated sample line and, if necessary, a glass fiber filter to a flame ionization analyzer (FIA).

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Gas VOC Concentration. A schematic of the measurement system is shown in Figure 204E-1. The main components are as follows:

4.1.1 Sample Probe. Stainless steel or equivalent. The probe shall be heated to prevent VOC condensation.

4.1.2 Calibration Valve Assembly. Three-way valve assembly at the outlet of the sample probe to direct the zero and calibration gases to the analyzer. Other methods, such as quick-connect lines, to route calibration gases to the outlet of the sample probe are acceptable.

4.1.3 Sample Line. Stainless steel or Teflon tubing to transport the sample gas to the analyzer. The sample line must be heated to prevent condensation.

4.1.4 Sample Pump. A leak-free pump, to pull the sample gas through the system at a flow rate sufficient to minimize the response time of the measurement system. The components of the pump that contact the gas stream shall be constructed of stainless steel or Teflon. The sample pump must be heated to prevent condensation.

4.1.5 Sample Flow Rate Control. A sample flow rate control valve and rotameter, or equivalent, to maintain a constant sampling rate within 10 percent. The flow rate control valve and rotameter must be heated to prevent condensation. A control valve may also be located on the sample pump bypass loop to assist in controlling the sample pressure and flow rate.

4.1.6 Sample Gas Manifold. Capable of diverting a portion of the sample gas stream to the FIA, and the remainder to the bypass discharge vent. The manifold components shall be constructed of stainless steel or Teflon. If emissions are to be measured at multiple locations, the measurement system shall be designed to use separate sampling probes, lines, and pumps for each measurement location, and a common sample gas manifold and FIA. The sample gas manifold must be heated to prevent condensation.

4.1.7 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated to the Administrator's satisfaction that they would provide equally accurate measurements. The system shall be capable of meeting or exceeding the following specifications:

4.1.7.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.1.7.2 Calibration Drift. Less than ± 3.0 percent of the span value.

4.1.7.3 Calibration Error. Less than ± 5.0 percent of the calibration gas value.

4.1.7.4 Response Time. Less than 30 seconds.

4.1.8 Integrator/Data Acquisition System. An analog or digital device or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data. The minimum data sampling frequency for computing average or integrated values is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2 Uncaptured Emissions Volumetric Flow Rate.

4.2.1 Flow Direction Indicators. Any means of indicating inward or outward flow, such as light plastic film or paper streamers, smoke tubes, filaments, and sensory perception.

4.2.2 Method 2 or 2A Apparatus. For determining volumetric flow rate. Anemometers or similar devices calibrated according to the manufacturer's instructions may be used

when low velocities are present. Vane anemometers (Young-maximum response propeller), specialized pitots with electronic manometers (e.g., Shortridge Instruments Inc., Airdata Multimeter 860) are commercially available with measurement thresholds of 15 and 8 mpm (50 and 25 fpm), respectively.

4.2.3 Method 3 Apparatus and Reagents. For determining molecular weight of the gas stream. An estimate of the molecular weight of the gas stream may be used if approved by the Administrator.

4.2.4 Method 4 Apparatus and Reagents. For determining moisture content, if necessary.

4.3 Building Enclosure. The criteria for an acceptable BE are specified in Method 204.

5. Reagents and Standards

5.1 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.1.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H_2 /60 percent He or 40 percent H_2 /60 percent N_2 gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.1.2 Carrier Gas. High purity air with less than 1 ppm of organic material (propane or carbon equivalent) or less than 0.1 percent of the span value, whichever is greater.

5.1.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentrations of 20-30, 45-55, and 70-80 percent of the span value in air, respectively. Other calibration values and other span values may be used if it can be shown to the Administrator's satisfaction that equally accurate measurements would be achieved.

5.2 Particulate Filter. An in-stack or an out-of-stack glass fiber filter is recommended if exhaust gas particulate loading is significant. An out-of-stack filter must be heated to prevent any condensation unless it

can be demonstrated that no condensation occurs.

6. Quality Control

6.1 Required instrument quality control parameters are found in the following sections:

6.1.1 The FIA system must be calibrated as specified in section 7.1.

6.1.2 The system drift check must be performed as specified in section 7.2.

6.1.3 The system check must be conducted as specified in section 7.3.

6.2 Audits.

6.2.1 Analysis Audit Procedure. Immediately before each test, analyze an audit cylinder as described in section 7.2. The analysis audit must agree with the audit cylinder concentration within 10 percent.

6.2.2 Audit Samples and Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.2.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calibration and Standardization

7.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero- and the high-range calibration gases, and adjust the analyzer calibration to provide the proper responses. Inject the low- and mid-range gases and record the responses of the measurement system. The

calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system.

7.2 Systems Drift Checks. Select the calibration gas that most closely approximates the concentration of the captured emissions for conducting the drift checks. Introduce the zero and calibration gases at the calibration valve assembly and verify that the appropriate gas flow rate and pressure are present at the FIA. Record the measurement system responses to the zero and calibration gases. The performance of the system is acceptable if the difference between the drift check measurement and the value obtained in section 7.1 is less than 3 percent of the span value. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. Conduct a system drift check at the end of each run.

7.3 System Check. Inject the high-range calibration gas at the inlet of the sampling probe and record the response. The performance of the system is acceptable if the measurement system response is within 5 percent of the value obtained in section 7.1 for the high-range calibration gas. Conduct a system check before each test run.

8. Procedure

8.1 Preliminary Determinations. The following points are considered exhaust points and should be measured for volumetric flow rates and VOC concentrations:

8.1.1 Forced Draft Openings. Any opening in the facility with an exhaust fan. Determine the volumetric flow rate according to Method 2.

8.1.2 Roof Openings. Any openings in the roof of a facility which does not contain fans are considered to be exhaust points. Determine volumetric flow rate from these openings. Use the appropriate velocity measurement devices (e.g., propeller anemometers).

8.2 Determination of Flow Rates.

8.2.1 Measure the volumetric flow rate at all locations identified as exhaust points in section 8.1. Divide each exhaust opening into nine equal areas for rectangular openings and into eight equal areas for circular openings.

8.2.2 Measure the velocity at each site at least once every hour during each sampling run using Method 2 or 2A, if applicable, or using the low velocity instruments in section 4.2.2.

8.3 Determination of VOC Content of Uncaptured Emissions.

8.3.1 Analysis Duration. Measure the VOC responses at each uncaptured emissions point during the entire test run or, if applicable, while the process is operating. If there are multiple emissions locations, design a sampling system to allow a single FIA to be used to determine the VOC responses at all sampling locations.

8.3.2 Gas VOC Concentration.

8.3.2.1 Assemble the sample train as shown in Figure 204E-1. Calibrate the FIA and conduct a system check according to the procedures in sections 7.1 and 7.3, respectively.

8.3.2.2 Install the sample probe so that the probe is centrally located in the stack, pipe, or duct, and is sealed tightly at the stack port connection.

8.3.2.3 Inject zero gas at the calibration valve assembly. Allow the measurement system response to reach zero. Measure the system response time as the time required for the system to reach the effluent concentration after the calibration valve has been returned to the effluent sampling position.

8.3.2.4 Conduct a system check before, and a system drift check after, each sampling run according to the procedures in sections 7.2 and 7.3. If the drift check following a run indicates unacceptable performance (see section 7.3), the run is not valid. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. The tester may elect to perform drift checks during the run, not to exceed one drift check per hour.

8.3.2.5 Verify that the sample lines, filter, and pump temperatures are $120 \pm 5^\circ\text{C}$.

8.3.2.6 Begin sampling at the start of the test period and continue to sample during the entire run. Record the starting and ending times, and any required process information, as appropriate. If multiple emission locations are sampled using a single FIA, sample at each location for the same amount of time (e.g., 2 minutes) and continue to switch from one location to another for the entire test run. Be sure that total sampling time at each location is the same at the end of the test run. Collect at least four separate measurements from each sample point during each hour of testing. Disregard the response measurements at each sampling location until 2 times the response time of the measurement system has elapsed. Continue sampling for at least 1 minute, and record the concentration measurements.

8.4 Alternative Procedure. The direct interface sampling and analysis procedure described in section 7.2 of Method 18 may be

used to determine the gas VOC concentration. The system must be designed to collect and analyze at least one sample every 10 minutes. If the alternative procedure is used to determine the VOC concentration of the uncaptured emissions in a gas/gas protocol, it must also be used to determine the VOC concentration of the captured emissions. If a tester wishes to conduct a liquid/gas protocol using a gas chromatograph, the tester must use Method 204F for the liquid stream. A gas chromatograph is not an acceptable alternative to the FIA in Method 204A.

9. Data Analysis and Calculations

9.1 Nomenclature.

C_{DH} =average measured concentration for the drift check calibration gas, ppm propane.

C_{DO} =average system drift check concentration for zero concentration gas, ppm propane.

C_{Fj} =corrected average VOC concentration of uncaptured emissions at point j, ppm propane.

C_H =actual concentration of the drift check calibration gas, ppm propane.

C_j =uncorrected average VOC concentration measured at point j, ppm propane.

F_B =total VOC content of uncaptured emissions from the building, kg.

$K_1=1.830 \times 10^{-6}$ kg/(m³-ppm).

n=number of measurement points.

Q_{Fj} =average effluent volumetric flow rate corrected to standard conditions at uncaptured emissions point j, m³/min.

Θ_F =total duration of CE sampling run, min.

9.2 Calculations

9.2.1 Total VOC Uncaptured Emissions from the Building.

$$F_B = \sum_{j=1}^n C_{Fj} Q_{Fj} \Theta_F K_1 \quad \text{Eq. 204E-1}$$

9.2.2 VOC Concentration of the Uncaptured Emissions at Point j.

$$C_{Fj} = (C_j - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204E-2}$$

10. Method Performance

The measurement uncertainties are estimated for each uncaptured emissions point as follows: $Q_{Fj}=\pm 10.0$ percent and $C_{Fj}=\pm 5.0$ percent. Based on these numbers, the probable uncertainty for F_B is estimated at about ± 11.2 percent.

11. Diagrams

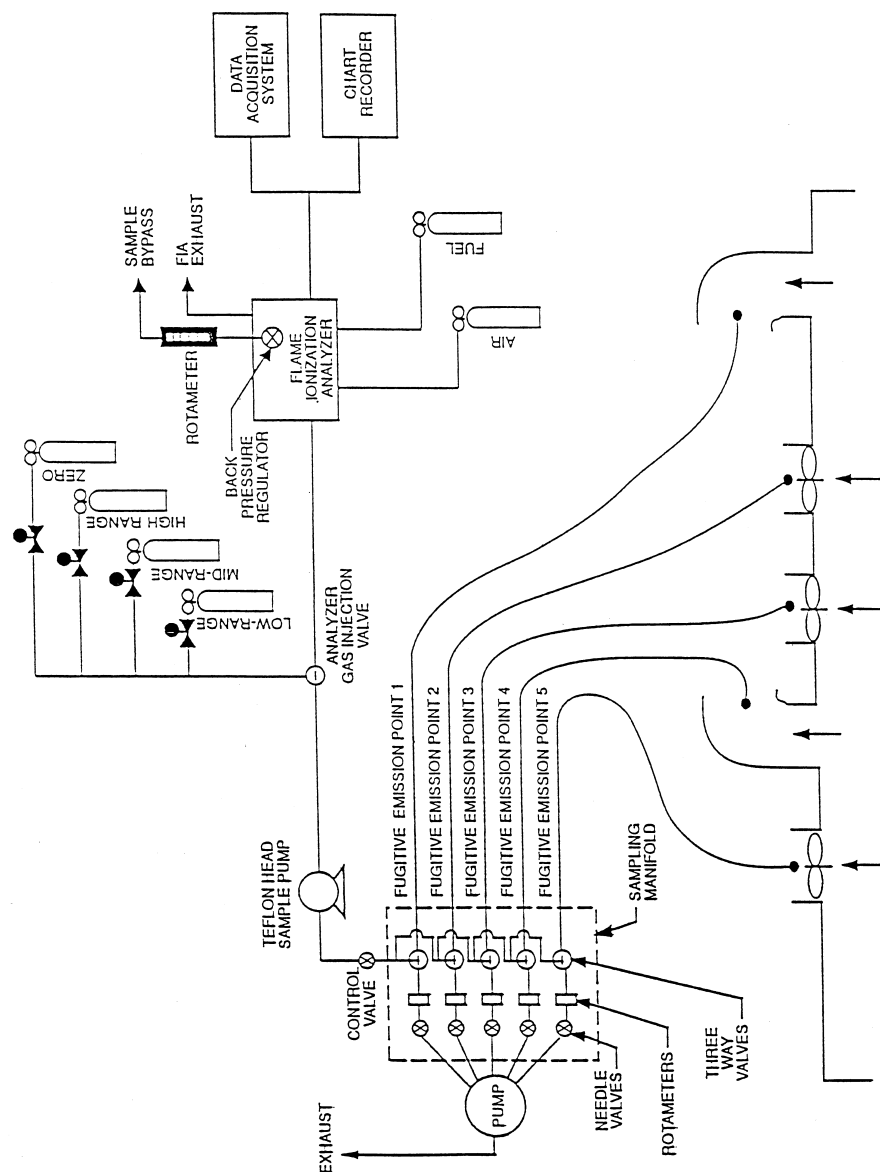


Figure 204E-1. Fugitive emissions measurement system.

**METHOD 204F—VOLATILE ORGANIC COMPOUNDS
CONTENT IN LIQUID INPUT STREAM (DIS-
TILLATION APPROACH)**

1. Introduction

1.1 Applicability. This procedure is applicable for determining the input of volatile organic compounds (VOC). It is intended to

be used as a segment in the development of liquid/gas protocols for determining VOC capture efficiency (CE) for surface coating and printing operations.

1.2 Principle. The amount of VOC introduced to the process (L) is the sum of the products of the weight (W) of each VOC containing liquid (ink, paint, solvent, etc.) used,

and its VOC content (V), corrected for a response factor (RF).

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

A sample of each coating used is distilled to separate the VOC fraction. The distillate is used to prepare a known standard for analysis by a flame ionization analyzer (FIA), calibrated against propane, to determine its RF.

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Liquid Weight.

4.1.1 Balances/Digital Scales. To weigh drums of VOC containing liquids to within 0.2 lb or 1.0 percent of the total weight of VOC liquid used.

4.1.2 Volume Measurement Apparatus (Alternative). Volume meters, flow meters, density measurement equipment, etc., as needed to achieve the same accuracy as direct weight measurements.

4.2 Response Factor Determination (FIA Technique). The VOC distillation system and Tedlar gas bag generation system apparatuses are shown in Figures 204F-1 and 204F-2, respectively. The following equipment is required:

4.2.1 Sample Collection Can. An appropriately-sized metal can to be used to collect VOC containing materials. The can must be constructed in such a way that it can be grounded to the coating container.

4.2.2 Needle Valves. To control gas flow.

4.2.3 Regulators. For calibration, dilution, and sweep gas cylinders.

4.2.4 Tubing and Fittings. Teflon and stainless steel tubing and fittings with diameters, lengths, and sizes determined by the connection requirements of the equipment.

4.2.5 Thermometer. Capable of measuring the temperature of the hot water and oil baths to within 1 °C.

4.2.6 Analytical Balance. To measure ± 0.01 mg.

4.2.7 Microliter Syringe. 10- μ l size.

4.2.8 Vacuum Gauge or Manometer. 0- to 760-mm (0- to 30-in.) Hg U-Tube manometer or vacuum gauge.

4.2.9 Hot Oil Bath, With Stirring Hot Plate. Capable of heating and maintaining a distillation vessel at 110 ± 3 °C.

4.2.10 Ice Water Bath. To cool the distillation flask.

4.2.11 Vacuum/Water Aspirator. A device capable of drawing a vacuum to within 20 mm Hg from absolute.

4.2.12 Rotary Evaporator System. Complete with folded inner coil, vertical style condenser, rotary speed control, and Teflon sweep gas delivery tube with valved inlet. Buchi Rotavapor or equivalent.

4.2.13 Ethylene Glycol Cooling/Circulating Bath. Capable of maintaining the condenser coil fluid at -10 °C.

4.2.14 Dry Gas Meter (DGM). Capable of measuring the dilution gas volume within 2 percent, calibrated with a spirometer or bubble meter, and equipped with a temperature gauge capable of measuring temperature within 3 °C.

4.2.15 Activated Charcoal/Mole Sieve Trap. To remove any trace level of organics picked up from the DGM.

4.2.16 Gas Coil Heater. Sufficient length of 0.125-inch stainless steel tubing to allow heating of the dilution gas to near the water bath temperature before entering the volatilization vessel.

4.2.17 Water Bath, With Stirring Hot Plate. Capable of heating and maintaining a volatilization vessel and coil heater at a temperature of 100 ± 5 °C.

4.2.18 Volatilization Vessel. 50-ml midjet impinger fitted with a septum top and loosely filled with glass wool to increase the volatilization surface.

4.2.19 Tedlar Gas Bag. Capable of holding 30 liters of gas, flushed clean with zero air, leak tested, and evacuated.

4.2.20 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated that they would provide equally accurate measurements. The FIA instrument should be the same instrument used in the gaseous analyses adjusted with the same fuel, combustion air, and sample back-pressure (flow rate) settings. The system shall be capable of meeting or exceeding the following specifications:

4.2.20.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.2.20.2 Calibration Drift. Less than ± 3.0 percent of the span value.

4.2.20.3 Calibration Error. Less than ± 3.0 percent of the calibration gas value.

4.2.21 Integrator/Data Acquisition System. An analog or digital device or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data.

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The minimum data sampling frequency for computing average or integrated value is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2.22 Chart Recorder (Optional). A chart recorder or similar device is recommended to provide a continuous analog display of the measurement results during the liquid sample analysis.

5. Reagents and Standards

5.1 Zero Air. High purity air with less than 1 ppm of organic material (as propane) or less than 0.1 percent of the span value, whichever is greater. Used to supply dilution air for making the Tedlar bag gas samples.

5.2 THC Free N₂. High purity N₂ with less than 1 ppm THC. Used as sweep gas in the rotary evaporator system.

5.3 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.3.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H₂/60 percent He, or 40 percent H₂/60 percent N₂ mixture is recommended to avoid fuels with oxygen to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.3.2 Combustion Air. High purity air with less than 1 ppm of organic material (as propane) or less than 0.1 percent of the span value, whichever is greater.

5.3.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentration of 20-30, 45-55, and 70-80 percent of the span value in air, respectively. Other calibration values and other span values may be used if it can be shown that equally accurate measurements would be achieved.

5.3.4 System Calibration Gas. Gas mixture standard containing propane in air, approximating the VOC concentration expected for the Tedlar bag gas samples.

6. Quality Control

6.1 Required instrument quality control parameters are found in the following sections:

6.1.1 The FIA system must be calibrated as specified in section 7.1.

6.1.2 The system drift check must be performed as specified in section 7.2.

6.2 Precision Control. A minimum of one sample in each batch must be distilled and analyzed in duplicate as a precision control. If the results of the two analyses differ by more than ± 10 percent of the mean, then the system must be reevaluated and the entire batch must be redistilled and analyzed.

6.3 Audits.

6.3.1 Audit Procedure. Concurrently, analyze the audit sample and a set of compliance samples in the same manner to evaluate the technique of the analyst and the standards preparation. The same analyst, analytical reagents, and analytical system shall be used both for compliance samples and the EPA audit sample. If this condition is met, auditing of subsequent compliance analyses for the same enforcement agency within 30 days is not required. An audit sample set may not be used to validate different sets of compliance samples under the jurisdiction of different enforcement agencies, unless prior arrangements are made with both enforcement agencies.

6.3.2 Audit Samples. Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.3.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calibration and Standardization

7.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero and the high-range calibration gases and adjust the analyzer calibration to provide the proper responses. Inject the low and mid-range gases and record the responses of the measurement system. The calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system. A calibration curve consisting of zero gas and two calibration levels must be performed at the beginning and end of each batch of samples.

7.2 Systems Drift Checks. After each sample, repeat the system calibration checks in section 7.1 before any adjustments to the FIA or measurement system are made. If the zero or calibration drift exceeds ± 3 percent of the span value, discard the result and repeat the analysis. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run.

8. Procedures

8.1 Determination of Liquid Input Weight

8.1.1 Weight Difference. Determine the amount of material introduced to the process as the weight difference of the feed material before and after each sampling run. In determining the total VOC containing liquid usage, account for: (a) The initial (beginning) VOC containing liquid mixture; (b) any solvent added during the test run; (c) any coating added during the test run; and (d) any residual VOC containing liquid mixture remaining at the end of the sample run.

8.1.1.1 Identify all points where VOC containing liquids are introduced to the process. To obtain an accurate measurement of VOC containing liquids, start with an empty fountain (if applicable). After completing the run, drain the liquid in the fountain back into the liquid drum (if possible), and weigh the drum again. Weigh the VOC containing liquids to ± 0.5 percent of the total weight (full) or ± 1.0 percent of the total weight of VOC containing liquid used during the sam-

ple run, whichever is less. If the residual liquid cannot be returned to the drum, drain the fountain into a preweighed empty drum to determine the final weight of the liquid.

8.1.1.2 If it is not possible to measure a single representative mixture, then weigh the various components separately (e.g., if solvent is added during the sampling run, weigh the solvent before it is added to the mixture). If a fresh drum of VOC containing liquid is needed during the run, then weigh both the empty drum and fresh drum.

8.1.2 Volume Measurement (Alternative). If direct weight measurements are not feasible, the tester may use volume meters and flow rate meters (and density measurements) to determine the weight of liquids used if it can be demonstrated that the technique produces results equivalent to the direct weight measurements. If a single representative mixture cannot be measured, measure the components separately.

8.2 Determination of VOC Content in Input Liquids

8.2.1 Collection of Liquid Samples.

8.2.1.1 Collect a 1-pint or larger sample of the VOC containing liquid mixture at each application location at the beginning and end of each test run. A separate sample should be taken of each VOC containing liquid added to the application mixture during the test run. If a fresh drum is needed during the sampling run, then obtain a sample from the fresh drum.

8.2.1.2 When collecting the sample, ground the sample container to the coating drum. Fill the sample container as close to the rim as possible to minimize the amount of headspace.

8.2.1.3 After the sample is collected, seal the container so the sample cannot leak out or evaporate.

8.2.1.4 Label the container to identify clearly the contents.

8.2.2 Distillation of VOC.

8.2.2.1 Assemble the rotary evaporator as shown in Figure 204F-1.

8.2.2.2 Leak check the rotary evaporation system by aspirating a vacuum of approximately 20 mm Hg from absolute. Close up the system and monitor the vacuum for approximately 1 minute. If the vacuum falls more than 25 mm Hg in 1 minute, repair leaks and repeat. Turn off the aspirator and vent vacuum.

8.2.2.3 Deposit approximately 20 ml of sample (inks, paints, etc.) into the rotary evaporation distillation flask.

8.2.2.4 Install the distillation flask on the rotary evaporator.

8.2.2.5 Immerse the distillate collection flask into the ice water bath.

8.2.2.6 Start rotating the distillation flask at a speed of approximately 30 rpm.

8.2.2.7 Begin heating the vessel at a rate of 2 to 3 °C per minute.

8.2.2.8 After the hot oil bath has reached a temperature of 50 °C or pressure is evident on the mercury manometer, turn on the aspirator and gradually apply a vacuum to the evaporator to within 20 mm Hg of absolute. Care should be taken to prevent material burping from the distillation flask.

8.2.2.9 Continue heating until a temperature of 110 °C is achieved and maintain this temperature for at least 2 minutes, or until the sample has dried in the distillation flask.

8.2.2.10 Slowly introduce the N₂ sweep gas through the purge tube and into the distillation flask, taking care to maintain a vacuum of approximately 400-mm Hg from absolute.

8.2.2.11 Continue sweeping the remaining solvent VOC from the distillation flask and condenser assembly for 2 minutes, or until all traces of condensed solvent are gone from the vessel. Some distillate may remain in the still head. This will not affect solvent recovery ratios.

8.2.2.12 Release the vacuum, disassemble the apparatus and transfer the distillate to a labeled, sealed vial.

8.2.3 Preparation of VOC standard bag sample.

8.2.3.1 Assemble the bag sample generation system as shown in Figure 204F-2 and bring the water bath up to near boiling temperature.

8.2.3.2 Inflate the Tedlar bag and perform a leak check on the bag.

8.2.3.3 Evacuate the bag and close the bag inlet valve.

8.2.3.4 Record the current barometric pressure.

8.2.3.5 Record the starting reading on the dry gas meter, open the bag inlet valve, and start the dilution zero air flowing into the Tedlar bag at approximately 2 liters per minute.

8.2.3.6 The bag sample VOC concentration should be similar to the gaseous VOC concentration measured in the gas streams. The amount of liquid VOC required can be approximated using equations in section 9.2. Using Equation 204F-4, calculate C_{VOC} by assuming RF is 1.0 and selecting the desired gas concentration in terms of propane, C_{C3}. Assuming B_V is 20 liters, M_L, the approximate amount of liquid to be used to prepare the bag gas sample, can be calculated using Equation 204F-2.

8.2.3.7 Quickly withdraw an aliquot of the approximate amount calculated in section 8.2.3.6 from the distillate vial with the microliter syringe and record its weight from the analytical balance to the nearest 0.01 mg.

8.2.3.8 Inject the contents of the syringe through the septum of the volatilization vessel into the glass wool inside the vessel.

8.2.3.9 Reweigh and record the tare weight of the now empty syringe.

8.2.3.10 Record the pressure and temperature of the dilution gas as it is passed through the dry gas meter.

8.2.3.11 After approximately 20 liters of dilution gas have passed into the Tedlar bag, close the valve to the dilution air source and record the exact final reading on the dry gas meter.

8.2.3.12 The gas bag is then analyzed by FIA within 1 hour of bag preparation in accordance with the procedure in section 8.2.4.

8.2.4 Determination of VOC response factor.

8.2.4.1 Start up the FIA instrument using the same settings as used for the gaseous VOC measurements.

8.2.4.2 Perform the FIA analyzer calibration and linearity checks according to the procedure in section 7.1. Record the responses to each of the calibration gases and the back-pressure setting of the FIA.

8.2.4.3 Connect the Tedlar bag sample to the FIA sample inlet and record the bag concentration in terms of propane. Continue the analyses until a steady reading is obtained for at least 30 seconds. Record the final reading and calculate the RF.

8.2.5 Determination of coating VOC content as VOC (V_U).

8.2.5.1 Determine the VOC content of the coatings used in the process using EPA Method 24 or 24A as applicable.

9. Data Analysis and Calculations

9.1. Nomenclature.

B_V=Volume of bag sample volume, liters.
 C_{C3}=Concentration of bag sample as propane, mg/liter.
 C_{VOC}=Concentration of bag sample as VOC, mg/liter.
 K=0.00183 mg propane/(liter-ppm propane)
 L=Total VOC content of liquid input, kg propane.
 M_L=Mass of VOC liquid injected into the bag, mg.
 M_V=Volume of gas measured by DGM, liters.
 P_M=Absolute DGM gas pressure, mm Hg.
 P_{STD}=Standard absolute pressure, 760 mm Hg.
 R_{C3}=FIA reading for bag gas sample, ppm propane.
 RF=Response factor for VOC in liquid, weight VOC/weight propane.
 RF_J=Response factor for VOC in liquid J, weight VOC/weight propane.
 T_M=DGM temperature, °K.
 T_{STD}=Standard absolute temperature, 293 °K.
 V_U=Initial VOC weight fraction of VOC liquid J.
 V_{FJ}=Final VOC weight fraction of VOC liquid J.
 V_{AJ}=VOC weight fraction of VOC liquid J added during the run.
 W_U=Weight of VOC containing liquid J at beginning of run, kg.
 W_{FJ}=Weight of VOC containing liquid J at end of run, kg.

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W_{Aj} =Weight of VOC containing liquid J added during the run, kg.

9.2 Calculations.

9.2.1 Bag sample volume.

$$B_V = \frac{M_V T_{STD} P_M}{T_M P_{STD}} \quad \text{Eq. 204F-1}$$

9.2.2 Bag sample VOC concentration.

$$C_{VOC} = \frac{M_L}{B_V} \quad \text{Eq. 204F-2}$$

9.2.3 Bag sample VOC concentration as propane.

$$C_{C_3} = R_{C_3} K \quad \text{Eq. 204F-3}$$

9.2.4 Response Factor.

$$RF = \frac{C_{VOC}}{C_{C_3}} \quad \text{Eq. 204F-4}$$

9.2.5 Total VOC Content of the Input VOC Containing Liquid.

$$L = \sum_{j=1}^n \frac{V_{rj} W_{rj}}{RF_j} - \sum_{j=1}^n \frac{V_{Fj} W_{Fj}}{RF_j} + \sum_{j=1}^n \frac{V_{Aj} W_{Aj}}{RF_j} \quad \text{Eq. 204F-5}$$

10. Diagrams

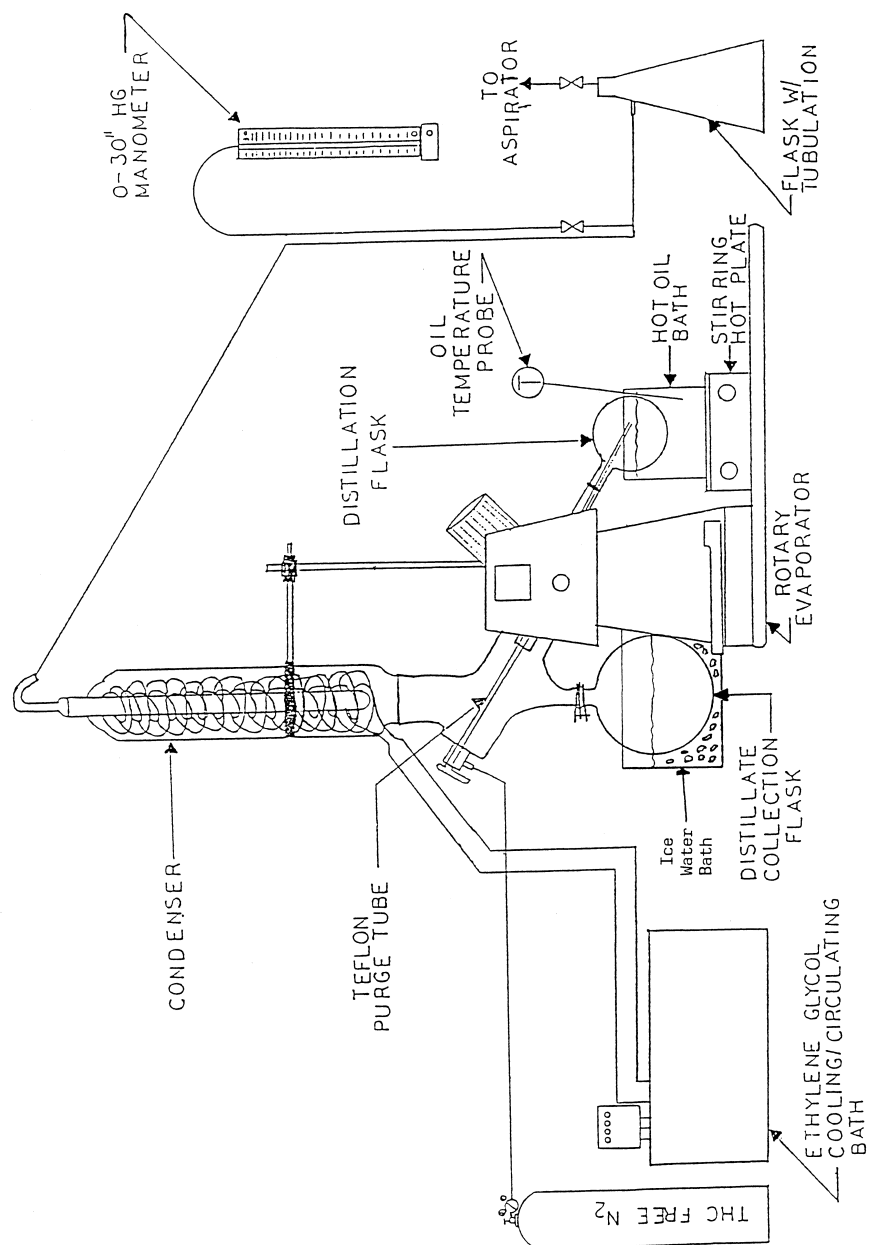


Figure 204F-1. VOC distillation system apparatus.

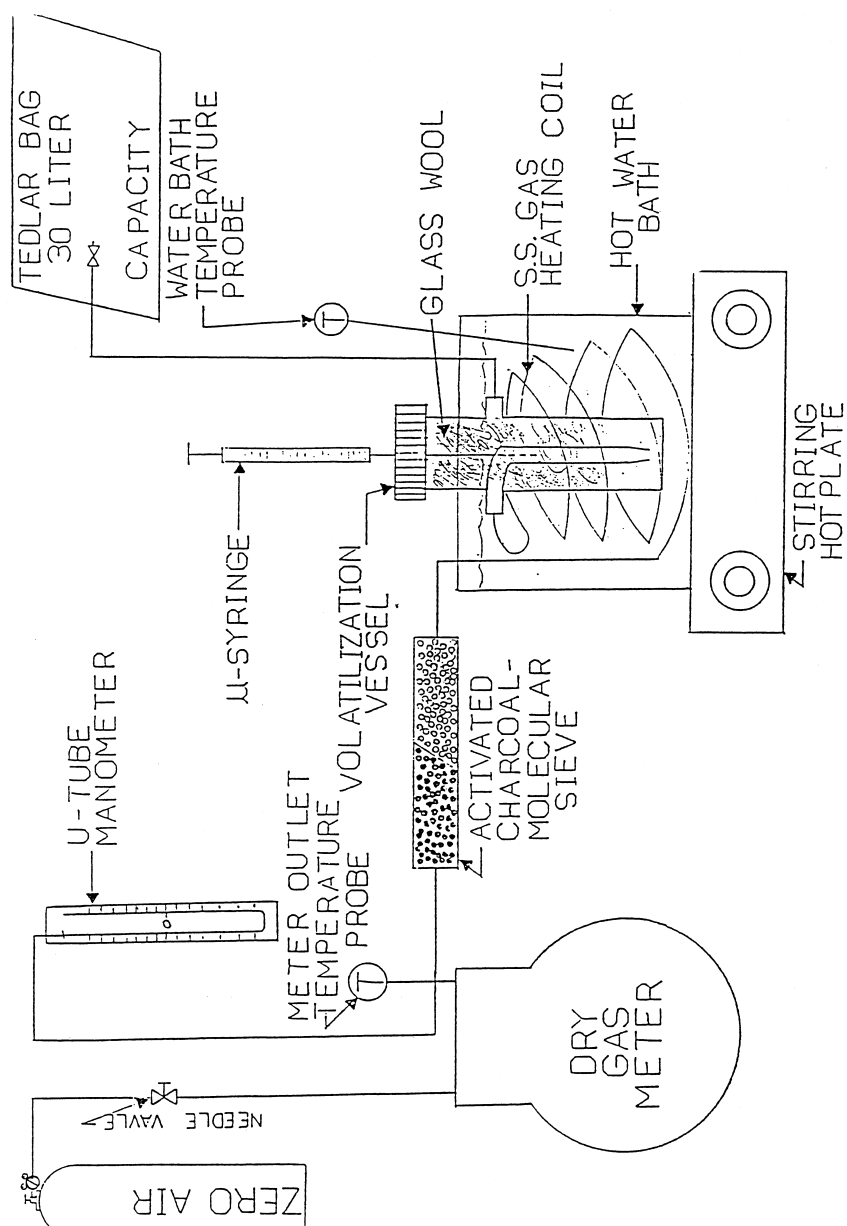


Figure 204F-2. Tedlar gas bag generation system apparatus.

METHOD 205—VERIFICATION OF GAS DILUTION SYSTEMS FOR FIELD INSTRUMENT CALIBRATIONS

1. Introduction

1.1 Applicability. A gas dilution system can provide known values of calibration gases through controlled dilution of high-level calibration gases with an appropriate dilution gas. The instrumental test methods in 40 CFR part 60—e.g., Methods 3A, 6C, 7E, 10, 15, 16, 20, 25A and 25B—require on-site, multi-point calibration using gases of known concentrations. A gas dilution system that produces known low-level calibration gases from high-level calibration gases, with a degree of confidence similar to that for Protocol¹ gases, may be used for compliance tests in lieu of multiple calibration gases when the gas dilution system is demonstrated to meet the requirements of this method. The Administrator may also use a gas dilution system in order to produce a wide range of Cylinder Gas Audit concentrations when conducting performance specifications according to appendix F, 40 CFR part 60. As long as the acceptance criteria of this method are met, this method is applicable to gas dilution systems using any type of dilution technology, not solely the ones mentioned in this method.

1.2 Principle. The gas dilution system shall be evaluated on one analyzer once during each field test. A precalibrated analyzer is chosen, at the discretion of the source owner or operator, to demonstrate that the gas dilution system produces predictable gas concentrations spanning a range of concentrations. After meeting the requirements of this method, the remaining analyzers may be calibrated with the dilution system in accordance to the requirements of the applicable method for the duration of the field test. In Methods 15 and 16, 40 CFR part 60, appendix A, reactive compounds may be lost in the gas dilution system. Also, in Methods 25A and 25B, 40 CFR part 60, appendix A, calibration with target compounds other than propane is allowed. In these cases, a laboratory evaluation is required once per year in order to assure the Administrator that the system will dilute these reactive gases without significant loss.

NOTE: The laboratory evaluation is required only if the source owner or operator plans to utilize the dilution system to prepare gases mentioned above as being reactive.

2. Specifications

2.1 Gas Dilution System. The gas dilution system shall produce calibration gases whose measured values are within ± 2 percent of the predicted values. The predicted values are calculated based on the certified concentration of the supply gas (Protocol gases, when

available, are recommended for their accuracy) and the gas flow rates (or dilution ratios) through the gas dilution system.

2.1.1 The gas dilution system shall be recalibrated once per calendar year using NIST-traceable primary flow standards with an uncertainty ≤ 0.25 percent. A label shall be affixed at all times to the gas dilution system listing the date of the most recent calibration, the due date for the next calibration, and the person or manufacturer who carried out the calibration. Follow the manufacturer's instructions for the operation and use of the gas dilution system. A copy of the manufacturer's instructions for the operation of the instrument, as well as the most recent recalibration documentation shall be made available for the Administrator's inspection upon request.

2.1.2 Some manufacturers of mass flow controllers recommend that flow rates below 10 percent of flow controller capacity be avoided; check for this recommendation and follow the manufacturer's instructions. One study has indicated that silicone oil from a positive displacement pump produces an interference in SO₂ analyzers utilizing ultraviolet fluorescence; follow laboratory procedures similar to those outlined in Section 3.1 in order to demonstrate the significance of any resulting effect on instrument performance.

2.2 High-Level Supply Gas. An EPA Protocol calibration gas is recommended, due to its accuracy, as the high-level supply gas.

2.3 Mid-Level Supply Gas. An EPA Protocol gas shall be used as an independent check of the dilution system. The concentration of the mid-level supply gas shall be within 10 percent of one of the dilution levels tested in Section 3.2.

3. Performance Tests

3.1 Laboratory Evaluation (Optional). If the gas dilution system is to be used to formulate calibration gases with reactive compounds (Test Methods 15, 16, and 25A/25B (only if using a calibration gas other than propane during the field test) in 40 CFR part 60, appendix A), a laboratory certification must be conducted once per calendar year for each reactive compound to be diluted. In the laboratory, carry out the procedures in Section 3.2 on the analyzer required in each respective test method to be laboratory certified (15, 16, or 25A and 25B for compounds other than propane). For each compound in which the gas dilution system meets the requirements in Section 3.2, the source must provide the laboratory certification data for the field test and in the test report.

3.2 Field Evaluation (Required). The gas dilution system shall be evaluated at the test site with an analyzer or monitor chosen by the source owner or operator. It is recommended that the source owner or operator choose a precalibrated instrument with a

high level of precision and accuracy for the purposes of this test. This method is not meant to replace the calibration requirements of test methods. In addition to the requirements in this method, all the calibration requirements of the applicable test method must also be met.

3.2.1 Prepare the gas dilution system according to the manufacturer's instructions. Using the high-level supply gas, prepare, at a minimum, two dilutions within the range of each dilution device utilized in the dilution system (unless, as in critical orifice systems, each dilution device is used to make only one dilution; in that case, prepare one dilution for each dilution device). Dilution device in this method refers to each mass flow controller, critical orifice, capillary tube, positive displacement pump, or any other device which is used to achieve gas dilution.

3.2.2 Calculate the predicted concentration for each of the dilutions based on the flow rates through the gas dilution system (or the dilution ratios) and the certified concentration of the high-level supply gas.

3.2.3 Introduce each of the dilutions from Section 3.2.1 into the analyzer or monitor one at a time and determine the instrument response for each of the dilutions.

3.2.4 Repeat the procedure in Section 3.2.3 two times, i.e., until three injections are made at each dilution level. Calculate the average instrument response for each triplicate injection at each dilution level. No single injection shall differ by more than ± 2 percent from the average instrument response for that dilution.

3.2.5 For each level of dilution, calculate the difference between the average concentration output recorded by the analyzer and the predicted concentration calculated in Section 3.2.2. The average concentration output from the analyzer shall be within ± 2 percent of the predicted value.

3.2.6 Introduce the mid-level supply gas directly into the analyzer, bypassing the gas dilution system. Repeat the procedure twice more, for a total of three mid-level supply gas injections. Calculate the average analyzer output concentration for the mid-level supply gas. The difference between the certified concentration of the mid-level supply gas and the average instrument response shall be within ± 2 percent.

3.3 If the gas dilution system meets the criteria listed in Section 3.2, the gas dilution system may be used throughout that field test. If the gas dilution system fails any of the criteria listed in Section 3.2, and the tester corrects the problem with the gas dilution system, the procedure in Section 3.2 must be repeated in its entirety and all the criteria in Section 3.2 must be met in order for the gas dilution system to be utilized in the test.

4. References

1. "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards," EPA-600/R93/224, Revised September 1993.

[55 FR 14249, Apr. 17, 1990; 55 FR 24687, June 18, 1990, as amended at 55 FR 37606, Sept. 12, 1990; 56 FR 6278, Feb. 15, 1991; 56 FR 65435, Dec. 17, 1991; 60 FR 28054, May 30, 1995; 62 FR 32502, June 16, 1997; 71 FR 55123, Sept. 21, 2006]

APPENDIXES N-O TO PART 51 [RESERVED]

APPENDIX P TO PART 51—MINIMUM EMISSION MONITORING REQUIREMENTS

1.0 *Purpose.* This appendix P sets forth the minimum requirements for continuous emission monitoring and recording that each State Implementation Plan must include in order to be approved under the provisions of 40 CFR 51.165(b). These requirements include the source categories to be affected; emission monitoring, recording, and reporting requirements for those sources; performance specifications for accuracy, reliability, and durability of acceptable monitoring systems; and techniques to convert emission data to units of the applicable State emission standard. Such data must be reported to the State as an indication of whether proper maintenance and operating procedures are being utilized by source operators to maintain emission levels at or below emission standards. Such data may be used directly or indirectly for compliance determination or any other purpose deemed appropriate by the State. Though the monitoring requirements are specified in detail, States are given some flexibility to resolve difficulties that may arise during the implementation of these regulations.

1.1 *Applicability.* The State plan shall require the owner or operator of an emission source in a category listed in this appendix to: (1) Install, calibrate, operate, and maintain all monitoring equipment necessary for continuously monitoring the pollutants specified in this appendix for the applicable source category; and (2) complete the installation and performance tests of such equipment and begin monitoring and recording within 18 months of plan approval or promulgation. The source categories and the respective monitoring requirements are listed below.

1.1.1 Fossil fuel-fired steam generators, as specified in paragraph 2.1 of this appendix, shall be monitored for opacity, nitrogen oxides emissions, sulfur dioxide emissions, and oxygen or carbon dioxide.

1.1.2 Fluid bed catalytic cracking unit catalyst regenerators, as specified in paragraph 2.4 of this appendix, shall be monitored for opacity.

1.1.3 Sulfuric acid plants, as specified in paragraph 2.3 of this appendix, shall be monitored for sulfur dioxide emissions.

1.1.4 Nitric acid plants, as specified in paragraph 2.2 of this appendix, shall be monitored for nitrogen oxides emissions.

1.2 *Exemptions.* The States may include provisions within their regulations to grant exemptions from the monitoring requirements of paragraph 1.1 of this appendix for any source which is:

1.2.1 Subject to a new source performance standard promulgated in 40 CFR part 60 pursuant to section 111 of the Clean Air Act; or

1.2.2 not subject to an applicable emission standard of an approved plan; or

1.2.3 scheduled for retirement within 5 years after inclusion of monitoring requirements for the source in appendix P, provided that adequate evidence and guarantees are provided that clearly show that the source will cease operations prior to such date.

1.3 *Extensions.* States may allow reasonable extensions of the time provided for installation of monitors for facilities unable to meet the prescribed timeframe (i.e., 18 months from plan approval or promulgation) provided the owner or operator of such facility demonstrates that good faith efforts have been made to obtain and install such devices within such prescribed timeframe.

1.4 *Monitoring System Malfunction.* The State plan may provide a temporary exemption from the monitoring and reporting requirements of this appendix during any period of monitoring system malfunction, provided that the source owner or operator shows, to the satisfaction of the State, that the malfunction was unavoidable and is being repaired as expeditiously as practicable.

2.0 *Minimum Monitoring Requirement.* States must, as a minimum, require the sources listed in paragraph 1.1 of this appendix to meet the following basic requirements.

2.1 *Fossil fuel-fired steam generators.* Each fossil fuel-fired steam generator, except as provided in the following subparagraphs, with an annual average capacity factor of greater than 30 percent, as reported to the Federal Power Commission for calendar year 1974, or as otherwise demonstrated to the State by the owner or operator, shall conform with the following monitoring requirements when such facility is subject to an emission standard of an applicable plan for the pollutant in question.

2.1.1 A continuous monitoring system for the measurement of opacity which meets the performance specifications of paragraph 3.1.1 of this appendix shall be installed, calibrated, maintained, and operated in accordance with the procedures of this appendix by the owner or operator of any such steam generator of greater than 250 million BTU per hour heat input except where:

2.1.1.1 gaseous fuel is the only fuel burned, or

2.1.1.2 oil or a mixture of gas and oil are the only fuels burned and the source is able to comply with the applicable particulate matter and opacity regulations without utilization of particulate matter collection equipment, and where the source has never been found, through any administrative or judicial proceedings, to be in violation of any visible emission standard of the applicable plan.

2.1.2 A continuous monitoring system for the measurement of sulfur dioxide which meets the performance specifications of paragraph 3.1.3 of this appendix shall be installed, calibrated, maintained, and operated on any fossil fuel-fired steam generator of greater than 250 million BTU per hour heat input which has installed sulfur dioxide pollutant control equipment.

2.1.3 A continuous monitoring system for the measurement of nitrogen oxides which meets the performance specification of paragraph 3.1.2 of this appendix shall be installed, calibrated, maintained, and operated on fossil fuel-fired steam generators of greater than 1000 million BTU per hour heat input when such facility is located in an Air Quality Control Region where the Administrator has specifically determined that a control strategy for nitrogen dioxide is necessary to attain the national standards, unless the source owner or operator demonstrates during source compliance tests as required by the State that such a source emits nitrogen oxides at levels 30 percent or more below the emission standard within the applicable plan.

2.1.4 A continuous monitoring system for the measurement of the percent oxygen or carbon dioxide which meets the performance specifications of paragraphs 3.1.4 or 3.1.5 of this appendix shall be installed, calibrated, operated, and maintained on fossil fuel-fired steam generators where measurements of oxygen or carbon dioxide in the flue gas are required to convert either sulfur dioxide or nitrogen oxides continuous emission monitoring data, or both, to units of the emission standard within the applicable plan.

2.2 *Nitric acid plants.* Each nitric acid plant of greater than 300 tons per day production capacity, the production capacity being expressed as 100 percent acid, located in an Air Quality Control Region where the Administrator has specifically determined that a control strategy for nitrogen dioxide is necessary to attain the national standard shall install, calibrate, maintain, and operate a continuous monitoring system for the measurement of nitrogen oxides which meets the performance specifications of paragraph 3.1.2 for each nitric acid producing facility within such plant.

2.3 *Sulfuric acid plants.* Each Sulfuric acid plant of greater than 300 tons per day production capacity, the production being expressed as 100 percent acid, shall install, calibrate, maintain and operate a continuous monitoring system for the measurement of sulfur dioxide which meets the performance specifications of paragraph 3.1.3 for each sulfuric acid producing facility within such plant.

2.4 *Fluid bed catalytic cracking unit catalyst regenerators at petroleum refineries.* Each catalyst regenerator for fluid bed catalytic cracking units of greater than 20,000 barrels per day fresh feed capacity shall install, calibrate, maintain, and operate a continuous monitoring system for the measurement of opacity which meets the performance specifications of paragraph 3.1.1.

3.0 *Minimum specifications.* All State plans shall require owners or operators of monitoring equipment installed to comply with this appendix, except as provided in paragraph 3.2, to demonstrate compliance with the following performance specifications.

3.1 *Performance specifications.* The performance specifications set forth in appendix B of part 60 are incorporated herein by reference, and shall be used by States to determine acceptability of monitoring equipment installed pursuant to this appendix except that (1) where reference is made to the "Administrator" in appendix B, part 60, the term *State* should be inserted for the purpose of this appendix (e.g., in Performance Specification 1, 1.2, " * * * monitoring systems subject to approval by the *Administrator*," should be interpreted as, " * * * monitoring systems subject to approval by the *State*"), and (2) where reference is made to the "Reference Method" in appendix B, part 60, the State may allow the use of either the State approved reference method or the Federally approved reference method as published in part 60 of this chapter. The Performance Specifications to be used with each type of monitoring system are listed below.

3.1.1 Continuous monitoring systems for measuring opacity shall comply with Performance Specification 1.

3.1.2 Continuous monitoring systems for measuring nitrogen oxides shall comply with Performance Specification 2.

3.1.3 Continuous monitoring systems for measuring sulfur dioxide shall comply with Performance Specification 2.

3.1.4 Continuous monitoring systems for measuring oxygen shall comply with Performance Specification 3.

3.1.5 Continuous monitoring systems for measuring carbon dioxide shall comply with Performance Specification 3.

3.2 *Exemptions.* Any source which has purchased an emission monitoring system(s) prior to September 11, 1974, may be exempt from meeting such test procedures prescribed in appendix B of part 60 for a period

not to exceed five years from plan approval or promulgation.

3.3 *Calibration Gases.* For nitrogen oxides monitoring systems installed on fossil fuel-fired steam generators the pollutant gas used to prepare calibration gas mixtures (Section 2.1, Performance Specification 2, appendix B, part 60) shall be nitric oxide (NO). For nitrogen oxides monitoring systems, installed on nitric acid plants the pollutant gas used to prepare calibration gas mixtures (Section 2.1, Performance Specification 2, appendix B, part 60 of this chapter) shall be nitrogen dioxide (NO₂). These gases shall also be used for daily checks under paragraph 3.7 of this appendix as applicable. For sulfur dioxide monitoring systems installed on fossil fuel-fired steam generators or sulfuric acid plants the pollutant gas used to prepare calibration gas mixtures (Section 2.1, Performance Specification 2, appendix B, part 60 of this chapter) shall be sulfur dioxide (SO₂). Span and zero gases should be traceable to National Bureau of Standards reference gases whenever these reference gases are available. Every six months from date of manufacture, span and zero gases shall be re-analyzed by conducting triplicate analyses using the reference methods in appendix A, part 60 of this chapter as follows: for sulfur dioxide, use Reference Method 6; for nitrogen oxides, use Reference Method 7; and for carbon dioxide or oxygen, use Reference Method 3. The gases may be analyzed at less frequent intervals if longer shelf lives are guaranteed by the manufacturer.

3.4 *Cycling times.* Cycling times include the total time a monitoring system requires to sample, analyze and record an emission measurement.

3.4.1 Continuous monitoring systems for measuring opacity shall complete a minimum of one cycle of operation (sampling, analyzing, and data recording) for each successive 10-second period.

3.4.2 Continuous monitoring systems for measuring oxides of nitrogen, carbon dioxide, oxygen, or sulfur dioxide shall complete a minimum of one cycle of operation (sampling, analyzing, and data recording) for each successive 15-minute period.

3.5 *Monitor location.* State plans shall require all continuous monitoring systems or monitoring devices to be installed such that representative measurements of emissions or process parameters (i.e., oxygen, or carbon dioxide) from the affected facility are obtained. Additional guidance for location of continuous monitoring systems to obtain representative samples are contained in the applicable Performance Specifications of appendix B of part 60 of this chapter.

3.6 *Combined effluents.* When the effluents from two or more affected facilities of similar design and operating characteristics are combined before being released to the atmosphere, the State plan may allow monitoring

systems to be installed on the combined effluent. When the affected facilities are not of similar design and operating characteristics, or when the effluent from one affected facility is released to the atmosphere through more than one point, the State should establish alternate procedures to implement the intent of these requirements.

3.7 *Zero and drift.* State plans shall require owners or operators of all continuous monitoring systems installed in accordance with the requirements of this appendix to record the zero and span drift in accordance with the method prescribed by the manufacturer of such instruments; to subject the instruments to the manufacturer's recommended zero and span check at least once daily unless the manufacturer has recommended adjustments at shorter intervals, in which case such recommendations shall be followed; to adjust the zero and span whenever the 24-hour zero drift or 24-hour calibration drift limits of the applicable performance specifications in appendix B of part 60 are exceeded; and to adjust continuous monitoring systems referenced by paragraph 3.2 of this appendix whenever the 24-hour zero drift or 24-hour calibration drift exceed 10 percent of the emission standard.

3.8 *Span.* Instrument span should be approximately 200 per cent of the expected instrument data display output corresponding to the emission standard for the source.

3.9 *Alternative procedures and requirements.* In cases where States wish to utilize different, but equivalent, procedures and requirements for continuous monitoring systems, the State plan must provide a description of such alternative procedures for approval by the Administrator. Some examples of situations that may require alternatives follow:

3.9.1 Alternative monitoring requirements to accommodate continuous monitoring systems that require corrections for stack moisture conditions (e.g., an instrument measuring steam generator SO₂ emissions on a wet basis could be used with an instrument measuring oxygen concentration on a dry basis if acceptable methods of measuring stack moisture conditions are used to allow accurate adjustments of the measured SO₂ concentration to dry basis.)

3.9.2 Alternative locations for installing continuous monitoring systems or monitoring devices when the owner or operator can demonstrate that installation at alternative locations will enable accurate and representative measurements.

3.9.3 Alternative procedures for performing calibration checks (e.g., some instruments may demonstrate superior drift characteristics that require checking at less frequent intervals).

3.9.4 Alternative monitoring requirements when the effluent from one affected facility or the combined effluent from two or more

identical affected facilities is released to the atmosphere through more than one point (e.g., an extractive, gaseous monitoring system used at several points may be approved if the procedures recommended are suitable for generating accurate emission averages).

3.9.5 Alternative continuous monitoring systems that do not meet the spectral response requirements in Performance Specification 1, appendix B of part 60, but adequately demonstrate a definite and consistent relationship between their measurements and the opacity measurements of a system complying with the requirements in Performance Specification 1. The State may require that such demonstration be performed for each affected facility.

4.0 *Minimum data requirements.* The following paragraphs set forth the minimum data reporting requirements necessary to comply with §51.214(d) and (e).

4.1 The State plan shall require owners or operators of facilities required to install continuous monitoring systems to submit a written report of excess emissions for each calendar quarter and the nature and cause of the excess emissions, if known. The averaging period used for data reporting should be established by the State to correspond to the averaging period specified in the emission test method used to determine compliance with an emission standard for the pollutant/source category in question. The required report shall include, as a minimum, the data stipulated in this appendix.

4.2 For opacity measurements, the summary shall consist of the magnitude in actual percent opacity of all one-minute (or such other time period deemed appropriate by the State) averages of opacity greater than the opacity standard in the applicable plan for each hour of operation of the facility. Average values may be obtained by integration over the averaging period or by arithmetically averaging a minimum of four equally spaced, instantaneous opacity measurements per minute. Any time period exempted shall be considered before determining the excess averages of opacity (e.g., whenever a regulation allows two minutes of opacity measurements in excess of the standard, the State shall require the source to report all opacity averages, in any one hour, in excess of the standard, minus the two-minute exemption). If more than one opacity standard applies, excess emissions data must be submitted in relation to all such standards.

4.3 For gaseous measurements the summary shall consist of emission averages, in the units of the applicable standard, for each averaging period during which the applicable standard was exceeded.

4.4 The date and time identifying each period during which the continuous monitoring system was inoperative, except for zero and

span checks, and the nature of system repairs or adjustments shall be reported. The State may require proof of continuous monitoring system performance whenever system repairs or adjustments have been made.

4.5 When no excess emissions have occurred and the continuous monitoring system(s) have not been inoperative, repaired, or adjusted, such information shall be included in the report.

4.6 The State plan shall require owners or operators of affected facilities to maintain a file of all information reported in the quarterly summaries, and all other data collected either by the continuous monitoring system or as necessary to convert monitoring data to the units of the applicable standard for a minimum of two years from the date of collection of such data or submission of such summaries.

5.0 *Data Reduction.* The State plan shall require owners or operators of affected facilities to use the following procedures for converting monitoring data to units of the standard where necessary.

5.1 For fossil fuel-fired steam generators the following procedures shall be used to convert gaseous emission monitoring data in parts per million to g/million cal (lb/million BTU) where necessary:

5.1.1 When the owner or operator of a fossil fuel-fired steam generator elects under paragraph 2.1.4 of this appendix to measure oxygen in the flue gases, the measurements of the pollutant concentration and oxygen concentration shall each be on a dry basis and the following conversion procedure used:

$$E = CF [20.9/20.9 - \%O_2]$$

5.1.2 When the owner or operator elects under paragraph 2.1.4 of this appendix to measure carbon dioxide in the flue gases, the measurement of the pollutant concentration and the carbon dioxide concentration shall each be on a consistent basis (wet or dry) and the following conversion procedure used:

$$E = CF_c (100 / \%CO_2)$$

5.1.3 The values used in the equations under paragraph 5.1 are derived as follows:

E = pollutant emission, g/million cal (lb/million BTU),

C = pollutant concentration, g/dscm (lb/dscf), determined by multiplying the average concentration (ppm) for each hourly period by 4.16×10^{-5} M g/dscm per ppm (2.64×10^{-9} M lb/dscf per ppm) where M = pollutant molecular weight, g/g-mole (lb/lb-mole). M = 64 for sulfur dioxide and 46 for oxides of nitrogen.

$\%O_2$, $\%CO_2$ = Oxygen or carbon dioxide volume (expressed as percent) determined with equipment specified under paragraph 4.1.4 of this appendix,

F, F_c = a factor representing a ratio of the volume of dry flue gases generated to the

calorific value of the fuel combusted (F), and a factor representing a ratio of the volume of carbon dioxide generated to the calorific value of the fuel combusted (F_c) respectively. Values of F and F_c are given in §60.45(f) of part 60, as applicable.

5.2 For sulfuric acid plants the owner or operator shall:

5.2.1 establish a conversion factor three times daily according to the procedures to §60.84(b) of this chapter;

5.2.2 multiply the conversion factor by the average sulfur dioxide concentration in the flue gases to obtain average sulfur dioxide emissions in Kg/metric ton (lb/short ton); and

5.2.3 report the average sulfur dioxide emission for each averaging period in excess of the applicable emission standard in the quarterly summary.

5.3 For nitric acid plants the owner or operator shall:

5.3.1 establish a conversion factor according to the procedures of §60.73(b) of this chapter;

5.3.2 multiply the conversion factor by the average nitrogen oxides concentration in the flue gases to obtain the nitrogen oxides emissions in the units of the applicable standard;

5.3.3 report the average nitrogen oxides emission for each averaging period in excess of the applicable emission standard, in the quarterly summary.

5.4 Any State may allow data reporting or reduction procedures varying from those set forth in this appendix if the owner or operator of a source shows to the satisfaction of the State that his procedures are at least as accurate as those in this appendix. Such procedures may include but are not limited to, the following:

5.4.1 Alternative procedures for computing emission averages that do not require integration of data (e.g., some facilities may demonstrate that the variability of their emissions is sufficiently small to allow accurate reduction of data based upon computing averages from equally spaced data points over the averaging period).

5.4.2 Alternative methods of converting pollutant concentration measurements to the units of the emission standards.

6.0 *Special Consideration.* The State plan may provide for approval, on a case-by-case basis, of alternative monitoring requirements different from the provisions of parts 1 through 5 of this appendix if the provisions of this appendix (i.e., the installation of a continuous emission monitoring system) cannot be implemented by a source due to physical plant limitations or extreme economic reasons. To make use of this provision, States must include in their plan specific criteria for determining those physical limitations or extreme economic situations

to be considered by the State. In such cases, when the State exempts any source subject to this appendix by use of this provision from installing continuous emission monitoring systems, the State shall set forth alternative emission monitoring and reporting requirements (e.g., periodic manual stack tests) to satisfy the intent of these regulations. Examples of such special cases include, but are not limited to, the following:

6.1 Alternative monitoring requirements may be prescribed when installation of a continuous monitoring system or monitoring device specified by this appendix would not provide accurate determinations of emissions (e.g., condensed, uncombined water vapor may prevent an accurate determination of opacity using commercially available continuous monitoring systems).

6.2 Alternative monitoring requirements may be prescribed when the affected facility is infrequently operated (e.g., some affected facilities may operate less than one month per year).

6.3 Alternative monitoring requirements may be prescribed when the State determines that the requirements of this appendix would impose an extreme economic burden on the source owner or operator.

6.4 Alternative monitoring requirements may be prescribed when the State determines that monitoring systems prescribed by this appendix cannot be installed due to physical limitations at the facility.

[40 FR 46247, Oct. 6, 1975, as amended at 51 FR 40675, Nov. 7, 1986]

APPENDIXES Q–R TO PART 51 [RESERVED]

APPENDIX S TO PART 51—EMISSION OFFSET INTERPRETATIVE RULING

I. INTRODUCTION

This appendix sets forth EPA's Interpretative Ruling on the preconstruction review requirements for stationary sources of air pollution (not including indirect sources) under 40 CFR subpart I and section 129 of the Clean Air Act Amendments of 1977, Public Law 95-95, (note under 42 U.S.C. 7502). A major new source or major modification which would locate in any area designated under section 107(d) of the Act as attainment or unclassifiable for ozone that is located in an ozone transport region or which would locate in an area designated in 40 CFR part 81, subpart C, as nonattainment for a pollutant for which the source or modification would be major may be allowed to construct only if the stringent conditions set forth below are met. These conditions are designed to insure that the new source's emissions will be controlled to the greatest degree possible; that more than equivalent offsetting emission reductions (*emission offsets*) will be obtained

from existing sources; and that there will be progress toward achievement of the NAAQS.

For each area designated as exceeding a NAAQS (nonattainment area) under 40 CFR part 81, subpart C, or for any area designated under section 107(d) of the Act as attainment or unclassifiable for ozone that is located in an ozone transport region, this Interpretative Ruling will be superseded after June 30, 1979 (a) by preconstruction review provisions of the revised SIP, if the SIP meets the requirements of Part D, Title 1, of the Act; or (b) by a prohibition on construction under the applicable SIP and section 110(a)(2)(I) of the Act, if the SIP does not meet the requirements of Part D. The Ruling will remain in effect to the extent not superseded under the Act. This prohibition on major new source construction does not apply to a source whose permit to construct was applied for during a period when the SIP was in compliance with Part D, or before the deadline for having a revised SIP in effect that satisfies Part D.

The requirement of this Ruling shall not apply to any major stationary source or major modification that was not subject to the Ruling as in effect on January 16, 1979, if the owner or operator:

A. Obtained all final Federal, State, and local preconstruction approvals or permits necessary under the applicable State Implementation Plan before August 7, 1980;

B. Commenced construction within 18 months from August 7, 1980, or any earlier time required under the applicable State Implementation Plan; and

C. Did not discontinue construction for a period of 18 months or more and completed construction within a reasonable time.

II. INITIAL SCREENING ANALYSES AND DETERMINATION OF APPLICABLE REQUIREMENTS

A. *Definitions*—For the purposes of this Ruling:

1. *Stationary source* means any building, structure, facility, or installation which emits or may emit a regulated NSR pollutant.

2. *Building, structure, facility or installation* means all of the pollutant-emitting activities which belong to the same industrial grouping, are located on one or more contiguous or adjacent properties, and are under the control of the same person (or persons under common control) except the activities of any vessel. Pollutant-emitting activities shall be considered as part of the same industrial grouping if they belong to the same "Major Group" (i.e., which have the same two digit code) as described in the *Standard Industrial Classification Manual*, 1972, as amended by the 1977 Supplement (U.S. Government Printing Office stock numbers 4101-0066 and 003-005-00176-0, respectively).

3. *Potential to emit* means the maximum capacity of a stationary source to emit a pollutant under its physical and operational design. Any physical or operational limitation on the capacity of the source to emit a pollutant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design only if the limitation or the effect it would have on emissions is federally enforceable. Secondary emissions do not count in determining the potential to emit of a stationary source.

4. (i) *Major stationary source* means:

(a) Any stationary source of air pollutants which emits, or has the potential to emit, 100 tons per year or more of any pollutant subject to regulation under the Act, except that lower emissions thresholds shall apply in areas subject to subpart 2, subpart 3, or subpart 4 of part D, title I of the Act, according to paragraphs II.A.4(i)(a)(1) through (6) of this Ruling.

(1) 50 tons per year of volatile organic compounds in any serious ozone nonattainment area.

(2) 50 tons per year of volatile organic compounds in an area within an ozone transport region, except for any severe or extreme ozone nonattainment area.

(3) 25 tons per year of volatile organic compounds in any severe ozone nonattainment area.

(4) 10 tons per year of volatile organic compounds in any extreme ozone nonattainment area.

(5) 50 tons per year of carbon monoxide in any serious nonattainment area for carbon monoxide, where stationary sources contribute significantly to carbon monoxide levels in the area (as determined under rules issued by the Administrator)

(6) 70 tons per year of PM-10 in any serious nonattainment area for PM-10;

(b) For the purposes of applying the requirements of paragraph IV.H of this Ruling to stationary sources of nitrogen oxides located in an ozone nonattainment area or in an ozone transport region, any stationary source which emits, or has the potential to emit, 100 tons per year or more of nitrogen oxides emissions, except that the emission thresholds in paragraphs II.A.4(i)(b)(1) through (6) of this Ruling apply in areas subject to subpart 2 of part D, title I of the Act.

(1) 100 tons per year or more of nitrogen oxides in any ozone nonattainment area classified as marginal or moderate.

(2) 100 tons per year or more of nitrogen oxides in any ozone nonattainment area classified as a transitional, submarginal, or incomplete or no data area, when such area is located in an ozone transport region.

(3) 100 tons per year or more of nitrogen oxides in any area designated under section 107(d) of the Act as attainment or

unclassifiable for ozone that is located in an ozone transport region.

(4) 50 tons per year or more of nitrogen oxides in any serious nonattainment area for ozone.

(5) 25 tons per year or more of nitrogen oxides in any severe nonattainment area for ozone.

(6) 10 tons per year or more of nitrogen oxides in any extreme nonattainment area for ozone; or

(c) Any physical change that would occur at a stationary source not qualifying under paragraph II.A.4(i)(a) or (b) of this Ruling as a major stationary source, if the change would constitute a major stationary source by itself.

(ii) A major stationary source that is major for volatile organic compounds or nitrogen oxides is major for ozone.

(iii) The fugitive emissions of a stationary source shall not be included in determining for any of the purposes of this ruling whether it is a major stationary source, unless the source belongs to one of the following categories of stationary sources:

(a) Coal cleaning plants (with thermal dryers);

(b) Kraft pulp mills;

(c) Portland cement plants;

(d) Primary zinc smelters;

(e) Iron and steel mills;

(f) Primary aluminum ore reduction plants;

(g) Primary copper smelters;

(h) Municipal incinerators capable of charging more than 250 tons of refuse per day;

(i) Hydrofluoric, sulfuric, or nitric acid plants;

(j) Petroleum refineries;

(k) Lime plants;

(l) Phosphate rock processing plants;

(m) Coke oven batteries;

(n) Sulfur recovery plants;

(o) Carbon black plants (furnace process);

(p) Primary lead smelters;

(q) Fuel conversion plants;

(r) Sintering plants;

(s) Secondary metal production plants;

(t) Chemical process plants;

(u) Fossil-fuel boilers (or combination thereof) totaling more than 250 million British thermal units per hour heat input;

(v) Petroleum storage and transfer units with a total storage capacity exceeding 300,000 barrels;

(w) Taconite ore processing plants;

(x) Glass fiber processing plants;

(y) Charcoal production plants;

(z) Fossil fuel-fired steam electric plants of more than 250 million British thermal units per hour heat input;

(aa) Any other stationary source category which, as of August 7, 1980, is being regulated under section 111 or 112 of the Act.

5. (i) *Major modification* means any physical change in or change in the method of operation of a major stationary source that would result in:

(a) A significant emissions increase of a regulated NSR pollutant (as defined in paragraph II.A.31 of this Ruling); and

(b) A significant net emissions increase of that pollutant from the major stationary source.

(ii) Any significant emissions increase (as defined in paragraph II.A.23 of this Ruling) from any emissions units or net emissions increase (as defined in paragraph II.A.6 of this Ruling) at a major stationary source that is significant for volatile organic compounds shall be considered significant for ozone.

(iii) A physical change or change in the method of operation shall not include:

(a) Routine maintenance, repair, and replacement;

(b) Use of an alternative fuel or raw material by reason of an order under section 2 (a) and (b) of the Energy Supply and Environmental Coordination Act of 1974 (or any superseding legislation) or by reason of a natural gas curtailment plan pursuant to the Federal Power Act;

(c) Use of an alternative fuel by reason of an order or rule under section 125 of the Act;

(d) Use of an alternative fuel at a steam generating unit to the extent that the fuel is generated from municipal solid waste;

(e) Use of an alternative fuel or raw material by a stationary source which:

(1) The source was capable of accommodating before December 21, 1976, unless such change would be prohibited under any federally enforceable permit condition which was established after December 21, 1976, pursuant to 40 CFR 52.21 or under regulations approved pursuant to 40 CFR subpart I or § 51.166; or

(2) The source is approved to use under any permit issued under this ruling;

(f) An increase in the hours of operation or in the production rate, unless such change is prohibited under any federally enforceable permit condition which was established after December 21, 1976 pursuant to 40 CFR 52.21 or under regulations approved pursuant to 40 CFR subpart I or § 51.166;

(g) Any change in ownership at a stationary source.

(iv) For the purpose of applying the requirements of paragraph IV.H of this Ruling to modifications at major stationary sources of nitrogen oxides located in ozone nonattainment areas or in ozone transport regions, whether or not subject with respect to ozone to subpart 2, part D, title I of the Act, any significant net emissions increase of nitrogen oxides is considered significant for ozone.

(v) Any physical change in, or change in the method of operation of, a major stationary source of volatile organic compounds

that results in any increase in emissions of volatile organic compounds from any discrete operation, emissions unit, or other pollutant emitting activity at the source shall be considered a significant net emissions increase and a major modification for ozone, if the major stationary source is located in an extreme ozone nonattainment area that is subject to subpart 2, part D, title I of the Act.

(vi) This definition shall not apply with respect to a particular regulated NSR pollutant when the major stationary source is complying with the requirements under paragraph IV.K of this ruling for a PAL for that pollutant. Instead, the definition at paragraph IV.K.2(viii) of this Ruling shall apply.

6.(i) *Net emissions increase* means, with respect to any regulated NSR pollutant emitted by a major stationary source, the amount by which the sum of the following exceeds zero:

(a) The increase in emissions from a particular physical change or change in the method of operation at a stationary source as calculated pursuant to paragraph IV.J of this Ruling; and

(b) Any other increases and decreases in actual emissions at the major stationary source that are contemporaneous with the particular change and are otherwise creditable. Baseline actual emissions for calculating increases and decreases under this paragraph II.A.6(i)(b) shall be determined as provided in paragraph II.A.30 of this Ruling, except that paragraphs II.A.30(i)(c) and II.A.30(ii)(d) of this Ruling shall not apply.

(ii) An increase or decrease in actual emissions is contemporaneous with the increase from the particular change only if it occurs between:

(a) The date five years before construction on the particular change commences and

(b) The date that the increase from the particular change occurs.

(iii) An increase or decrease in actual emissions is creditable only if the reviewing authority has not relied on it in issuing a permit for the source under this Ruling, which permit is in effect when the increase in actual emissions from the particular change occurs.

(iv) An increase in actual emissions is creditable only to the extent that the new level of actual emissions exceeds the old level.

(v) A decrease in actual emissions is creditable only to the extent that:

(a) The old level of actual emissions or the old level of allowable emissions, whichever is lower, exceeds the new level of actual emissions;

(b) It is enforceable as a practical matter at and after the time that actual construction on the particular change begins;

(c) The reviewing authority has not relied on it in issuing any permit under regulations approved pursuant to 40 CFR 51.165; and

(d) It has approximately the same qualitative significance for public health and welfare as that attributed to the increase from the particular change.

(vi) An increase that results from a physical change at a source occurs when the emissions unit on which construction occurred becomes operational and begins to emit a particular pollutant. Any replacement unit that requires shakedown becomes operational only after a reasonable shakedown period, not to exceed 180 days.

(vii) Paragraph II.A.13(ii) of this Ruling shall not apply for determining creditable increases and decreases or after a change.

7. *Emissions unit* means any part of a stationary source that emits or would have the potential to emit any regulated NSR pollutant and includes an electric utility steam generating unit as defined in paragraph II.A.21 of this Ruling. For purposes of this Ruling, there are two types of emissions units as described in paragraphs II.A.7(i) and (ii) of this Ruling.

(i) A new emissions unit is any emissions unit which is (or will be) newly constructed and which has existed for less than 2 years from the date such emissions unit first operated.

(ii) An existing emissions unit is any emissions unit that does not meet the requirements in paragraph II.A.7(i) of this Ruling.

8. *Secondary emissions* means emissions which would occur as a result of the construction or operation of a major stationary source or major modification, but do not come from the major stationary source or major modification itself. For the purpose of this Ruling, secondary emissions must be specific, well defined, quantifiable, and impact the same general area as the stationary source or modification which causes the secondary emissions. Secondary emissions include emissions from any offsite support facility which would not be constructed or increase its emissions except as a result of the construction or operation of the major stationary source or major modification. Secondary emissions do not include any emissions which come directly from a mobile source, such as emissions from the tailpipe of a motor vehicle, from a train, or from a vessel.

9. *Fugitive emissions* means those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.

10. (i) *Significant* means, in reference to a net emissions increase or the potential of a source to emit any of the following pollutants, a rate of emissions that would equal or exceed any of the following rates:

Pollutant and Emissions Rate

Carbon monoxide: 100 tons per year (tpy)

Nitrogen oxides: 40 tpy

Sulfur dioxide: 40 tpy

Ozone: 40 tpy of volatile organic compounds or NO_x

Lead: 0.6 tpy

Particulate matter: 25 tpy of particulate matter emissions

PM-10: 15 tpy PM-10

(ii) Notwithstanding the significant emissions rate for ozone in paragraph II.A.10(i) of this Ruling, significant means, in reference to an emissions increase or a net emissions increase, any increase in actual emissions of volatile organic compounds that would result from any physical change in, or change in the method of operation of, a major stationary source locating in a serious or severe ozone nonattainment area that is subject to subpart 2, part D, title I of the Act, if such emissions increase of volatile organic compounds exceeds 25 tons per year.

(iii) For the purposes of applying the requirements of paragraph IV.H of this Ruling to modifications at major stationary sources of nitrogen oxides located in an ozone nonattainment area or in an ozone transport region, the significant emission rates and other requirements for volatile organic compounds in paragraphs II.A.10(i), (ii), and (v) of this Ruling shall apply to nitrogen oxides emissions.

(iv) Notwithstanding the significant emissions rate for carbon monoxide under paragraph II.A.10(i) of this Ruling, significant means, in reference to an emissions increase or a net emissions increase, any increase in actual emissions of carbon monoxide that would result from any physical change in, or change in the method of operation of, a major stationary source in a serious nonattainment area for carbon monoxide if such increase equals or exceeds 50 tons per year, provided the Administrator has determined that stationary sources contribute significantly to carbon monoxide levels in that area.

(v) Notwithstanding the significant emissions rates for ozone under paragraphs II.A.10(i) and (ii) of this Ruling, any increase in actual emissions of volatile organic compounds from any emissions unit at a major stationary source of volatile organic compounds located in an extreme ozone nonattainment area that is subject to subpart 2, part D, title I of the Act shall be considered a significant net emissions increase.

11. *Allowable emissions* means the emissions rate calculated using the maximum rated capacity of the source (unless the source is subject to federally enforceable limits which restrict the operating rate, or hours of operation, or both) and the most stringent of the following:

(i) Applicable standards as set forth in 40 CFR parts 60 and 61;

(ii) Any applicable State Implementation Plan emissions limitation, including those with a future compliance date; or

(iii) The emissions rate specified as a federally enforceable permit condition, including those with a future compliance date.

12. *Federally enforceable* means all limitations and conditions which are enforceable by the Administrator, including those requirements developed pursuant to 40 CFR parts 60 and 61, requirements within any applicable State implementation plan, any permit requirements established pursuant to 40 CFR 52.21 or under regulations approved pursuant to 40 CFR part 51, subpart I, including operating permits issued under an EPA-approved program that is incorporated into the State implementation plan and expressly requires adherence to any permit issued under such program.

13. (i) *Actual emissions* means the actual rate of emissions of a regulated NSR pollutant from an emissions unit, as determined in accordance with paragraphs II.A.13(ii) through (iv) of this Ruling, except that this definition shall not apply for calculating whether a significant emissions increase has occurred, or for establishing a PAL under paragraph IV.K of this Ruling. Instead, paragraphs II.A.24 and 30 of this Ruling shall apply for those purposes.

(ii) In general, actual emissions as of a particular date shall equal the average rate, in tons per year, at which the unit actually emitted the pollutant during a consecutive 24-month period which precedes the particular date and which is representative of normal source operation. The reviewing authority shall allow the use of a different time period upon a determination that it is more representative of normal source operation. Actual emissions shall be calculated using the unit's actual operating hours, production rates, and types of materials processed, stored, or combusted during the selected time period.

(iii) The reviewing authority may presume that source-specific allowable emissions for the unit are equivalent to the actual emissions of the unit.

(iv) For any emissions unit that has not begun normal operations on the particular date, actual emissions shall equal the potential to emit of the unit on that date.

14. *Construction* means any physical change or change in the method of operation (including fabrication, erection, installation, demolition, or modification of an emissions unit) that would result in a change in emissions.

15. *Commence* as applied to construction of a major stationary source or major modification means that the owner or operator has all necessary preconstruction approvals or permits and either has:

(i) Begun, or caused to begin, a continuous program of actual on-site construction of the source, to be completed within a reasonable time; or

(ii) Entered into binding agreements or contractual obligations, which cannot be cancelled or modified without substantial loss to the owner or operator, to undertake a program of actual construction of the source to be completed within a reasonable time.

16. *Necessary preconstruction approvals or permits* means those permits or approvals required under Federal air quality control laws and regulations and those air quality control laws and regulations which are part of the applicable State Implementation Plan.

17. *Begin actual construction* means, in general, initiation of physical on-site construction activities on an emissions unit which are of a permanent nature. Such activities include, but are not limited to, installation of building supports and foundations, laying of underground pipework, and construction of permanent storage structures. With respect to a change in method of operating this term refers to those on-site activities other than preparatory activities which mark the initiation of the change.

18. *Lowest achievable emission rate (LAER)* means, for any source, the more stringent rate of emissions based on the following:

(i) The most stringent emissions limitation which is contained in the implementation plan of any State for such class or category of stationary source, unless the owner or operator of the proposed stationary source demonstrates that such limitations are not achievable; or

(ii) The most stringent emissions limitation which is achieved in practice by such class or category of stationary source. This limitation, when applied to a modification, means the lowest achievable emissions rate for the new or modified emissions units within the stationary source. In no event shall the application of this term permit a proposed new or modified stationary source to emit any pollutant in excess of the amount allowable under applicable new source standards of performance.

19. *Resource recovery facility* means any facility at which solid waste is processed for the purpose of extracting, converting to energy, or otherwise separating and preparing solid waste for reuse. Energy conversion facilities must utilize solid waste to provide more than 50 percent of the heat input to be considered a resource recovery facility under this Ruling.

20. *Volatile organic compounds (VOC)* is as defined in §51.100(s) of this part.

21. *Electric utility steam generating unit* means any steam electric generating unit that is constructed for the purpose of supplying more than one-third of its potential electric output capacity and more than 25 MW electrical output to any utility power

distribution system for sale. Any steam supplied to a steam distribution system for the purpose of providing steam to a steam-electric generator that would produce electrical energy for sale is also considered in determining the electrical energy output capacity of the affected facility.

22. *Pollution prevention* means any activity that through process changes, product reformulation or redesign, or substitution of less polluting raw materials, eliminates or reduces the release of air pollutants (including fugitive emissions) and other pollutants to the environment prior to recycling, treatment, or disposal; it does not mean recycling (other than certain "in-process recycling" practices), energy recovery, treatment, or disposal.

23. *Significant emissions increase* means, for a regulated NSR pollutant, an increase in emissions that is significant (as defined in paragraph II.A.10 of this Ruling) for that pollutant.

24. (i) *Projected actual emissions* means, the maximum annual rate, in tons per year, at which an existing emissions unit is projected to emit a regulated NSR pollutant in any one of the 5 years (12-month period) following the date the unit resumes regular operation after the project, or in any one of the 10 years following that date, if the project involves increasing the emissions unit's design capacity or its potential to emit of that regulated NSR pollutant and full utilization of the unit would result in a significant emissions increase or a significant net emissions increase at the major stationary source.

(ii) In determining the projected actual emissions under paragraph II.A.24(i) of this Ruling before beginning actual construction, the owner or operator of the major stationary source:

(a) Shall consider all relevant information, including but not limited to, historical operational data, the company's own representations, the company's expected business activity and the company's highest projections of business activity, the company's filings with the State or Federal regulatory authorities, and compliance plans under the approved plan; and

(b) Shall include fugitive emissions to the extent quantifiable, and emissions associated with startups, shutdowns, and malfunctions; and

(c) Shall exclude, in calculating any increase in emissions that results from the particular project, that portion of the unit's emissions following the project that an existing unit could have accommodated during the consecutive 24-month period used to establish the baseline actual emissions under paragraph II.A.30 of this Ruling and that are also unrelated to the particular project, including any increased utilization due to product demand growth; or,

(d) In lieu of using the method set out in paragraphs II.A.24(ii)(a) through (c) of this Ruling, may elect to use the emissions unit's potential to emit, in tons per year, as defined under paragraph II.A.3 of this Ruling.

25. *Nonattainment major new source review (NSR) program* means a major source preconstruction permit program that implements Sections I through VI of this Ruling, or a program that has been approved by the Administrator and incorporated into the plan to implement the requirements of §51.165 of this part. Any permit issued under such a program is a major NSR permit.

26. *Continuous emissions monitoring system (CEMS)* means all of the equipment that may be required to meet the data acquisition and availability requirements of this Ruling, to sample, condition (if applicable), analyze, and provide a record of emissions on a continuous basis.

27. *Predictive emissions monitoring system (PEMS)* means all of the equipment necessary to monitor process and control device operational parameters (for example, control device secondary voltages and electric currents) and other information (for example, gas flow rate, O₂ or CO₂ concentrations), and calculate and record the mass emissions rate (for example, lb/hr) on a continuous basis.

28. *Continuous parameter monitoring system (CPMS)* means all of the equipment necessary to meet the data acquisition and availability requirements of this Ruling, to monitor process and control device operational parameters (for example, control device secondary voltages and electric currents) and other information (for example, gas flow rate, O₂ or CO₂ concentrations), and to record average operational parameter value(s) on a continuous basis.

29. *Continuous emissions rate monitoring system (CERMS)* means the total equipment required for the determination and recording of the pollutant mass emissions rate (in terms of mass per unit of time).

30. *Baseline actual emissions* means the rate of emissions, in tons per year, of a regulated NSR pollutant, as determined in accordance with paragraphs II.A.30(i) through (iv) of this Ruling.

(i) For any existing electric utility steam generating unit, baseline actual emissions means the average rate, in tons per year, at which the unit actually emitted the pollutant during any consecutive 24-month period selected by the owner or operator within the 5-year period immediately preceding when the owner or operator begins actual construction of the project. The reviewing authority shall allow the use of a different time period upon a determination that it is more representative of normal source operation.

(a) The average rate shall include fugitive emissions to the extent quantifiable, and

emissions associated with startups, shutdowns, and malfunctions.

(b) The average rate shall be adjusted downward to exclude any non-compliant emissions that occurred while the source was operating above any emission limitation that was legally enforceable during the consecutive 24-month period.

(c) For a regulated NSR pollutant, when a project involves multiple emissions units, only one consecutive 24-month period must be used to determine the baseline actual emissions for the emissions units being changed. A different consecutive 24-month period can be used for each regulated NSR pollutant.

(d) The average rate shall not be based on any consecutive 24-month period for which there is inadequate information for determining annual emissions, in tons per year, and for adjusting this amount if required by paragraph II.A.30(i)(b) of this Ruling.

(ii) For an existing emissions unit (other than an electric utility steam generating unit), baseline actual emissions means the average rate, in tons per year, at which the emissions unit actually emitted the pollutant during any consecutive 24-month period selected by the owner or operator within the 10-year period immediately preceding either the date the owner or operator begins actual construction of the project, or the date a complete permit application is received by the reviewing authority for a permit required either under this Ruling or under a plan approved by the Administrator, whichever is earlier, except that the 10-year period shall not include any period earlier than November 15, 1990.

(a) The average rate shall include fugitive emissions to the extent quantifiable, and emissions associated with startups, shutdowns, and malfunctions.

(b) The average rate shall be adjusted downward to exclude any non-compliant emissions that occurred while the source was operating above an emission limitation that was legally enforceable during the consecutive 24-month period.

(c) The average rate shall be adjusted downward to exclude any emissions that would have exceeded an emission limitation with which the major stationary source must currently comply, had such major stationary source been required to comply with such limitations during the consecutive 24-month period. However, if an emission limitation is part of a maximum achievable control technology standard that the Administrator proposed or promulgated under part 63 of this chapter, the baseline actual emissions need only be adjusted if the State has taken credit for such emissions reductions in an attainment demonstration or maintenance plan.

(d) For a regulated NSR pollutant, when a project involves multiple emissions units,

only one consecutive 24-month period must be used to determine the baseline actual emissions for the emissions units being changed. A different consecutive 24-month period can be used for each regulated NSR pollutant.

(e) The average rate shall not be based on any consecutive 24-month period for which there is inadequate information for determining annual emissions, in tons per year, and for adjusting this amount if required by paragraphs II.A.30(ii)(b) and (c) of this Ruling.

(iii) For a new emissions unit, the baseline actual emissions for purposes of determining the emissions increase that will result from the initial construction and operation of such unit shall equal zero; and thereafter, for all other purposes, shall equal the unit's potential to emit.

(iv) For a PAL for a major stationary source, the baseline actual emissions shall be calculated for existing electric utility steam generating units in accordance with the procedures contained in paragraph II.A.30(i) of this Ruling, for other existing emissions units in accordance with the procedures contained in paragraph II.A.30(ii) of this Ruling, and for a new emissions unit in accordance with the procedures contained in paragraph II.A.30(iii) of this Ruling.

31. *Regulated NSR pollutant*, for purposes of this Ruling, means the following:

(i) Nitrogen oxides or any volatile organic compounds;

(ii) Any pollutant for which a national ambient air quality standard has been promulgated; or

(iii) Any pollutant that is a constituent or precursor of a general pollutant listed under paragraphs II.A.31(i) or (ii) of this Ruling, provided that a constituent or precursor pollutant may only be regulated under NSR as part of regulation of the general pollutant.

32. *Reviewing authority* means the State air pollution control agency, local agency, other State agency, Indian tribe, or other agency issuing permits under this Ruling or authorized by the Administrator to carry out a permit program under §§51.165 and 51.166 of this part, or the Administrator in the case of EPA-implemented permit programs under this Ruling or under §52.21 of this chapter.

33. *Project* means a physical change in, or change in the method of operation of, an existing major stationary source.

34. *Best available control technology (BACT)* means an emissions limitation (including a visible emissions standard) based on the maximum degree of reduction for each regulated NSR pollutant which would be emitted from any proposed major stationary source or major modification which the reviewing authority, on a case-by-case basis, taking into account energy, environmental, and

economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard under 40 CFR part 60 or 61. If the reviewing authority determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of BACT. Such standard shall, to the degree possible, set forth the emissions reduction achievable by implementation of such design, equipment, work practice or operation, and shall provide for compliance by means which achieve equivalent results.

35. *Prevention of Significant Deterioration (PSD) permit* means any permit that is issued under a major source preconstruction permit program that has been approved by the Administrator and incorporated into the plan to implement the requirements of §51.166 of this chapter, or under the program in §52.21 of this chapter.

36. *Federal Land Manager* means, with respect to any lands in the United States, the Secretary of the department with authority over such lands.

B. *Review of all sources for emission limitation compliance.* The reviewing authority must examine each proposed major new source and proposed major modification¹ to determine if such a source will meet all applicable emission requirements in the SIP, any applicable new source performance standard in 40 CFR part 60, or any national emission standard for hazardous air pollutants in 40 CFR part 61. If the reviewing authority determines that the proposed major new source cannot meet the applicable emission requirements, the permit to construct must be denied.

C. *Review of specified sources for air quality impact.* In addition, the reviewing authority must determine whether the major stationary source or major modification would be constructed in an area designated in 40 CFR 81.300 *et seq.* as nonattainment for a pollutant for which the stationary source or modification is major.

D.-E. [Reserved]

¹Hereafter the term *source* will be used to denote both any source and any modification.

F. *Fugitive emissions sources.* Section IV. A. of this Ruling shall not apply to a source or modification that would be a major stationary source or major modification only if fugitive emissions, to the extent quantifiable, are considered in calculating the potential to emit of the stationary source or modification and the source does not belong to any of the following categories:

- (1) Coal cleaning plants (with thermal dryers);
- (2) Kraft pulp mills;
- (3) Portland cement plants;
- (4) Primary zinc smelters;
- (5) Iron and steel mills;
- (6) Primary aluminum ore reduction plants;
- (7) Primary copper smelters;
- (8) Municipal incinerators capable of charging more than 250 tons of refuse per day;
- (9) Hydrofluoric, sulfuric, or nitric acid plants;
- (10) Petroleum refineries;
- (11) Lime plants;
- (12) Phosphate rock processing plants;
- (13) Coke oven batteries;
- (14) Sulfur recovery plants;
- (15) Carbon black plants (furnace process);
- (16) Primary lead smelters;
- (17) Fuel conversion plants;
- (18) Sintering plants;
- (19) Secondary metal production plants;
- (20) Chemical process plants;
- (21) Fossil-fuel boilers (or combination thereof) totaling more than 250 million British thermal units per hour heat input;
- (22) Petroleum storage and transfer units with a total storage capacity exceeding 300,000 barrels;
- (23) Taconite ore processing plants;
- (24) Glass fiber processing plants;
- (25) Charcoal production plants;
- (26) Fossil fuel-fired steam electric plants of more than 250 million British thermal units per hour heat input;
- (27) Any other stationary source category which, as of August 7, 1980, is being regulated under section 111 or 112 of the Act.

G. *Secondary emissions.* Secondary emissions need not be considered in determining whether the emission rates in Section II.C. above would be exceeded. However, if a source is subject to this Ruling on the basis of the direct emissions from the source, the applicable conditions of this Ruling must also be met for secondary emissions. However, secondary emissions may be exempt from Conditions 1 and 2 of Section IV. Also, since EPA's authority to perform or require indirect source review relating to mobile sources regulated under Title II of the Act (motor vehicles and aircraft) has been restricted by statute, consideration of the indirect impacts of motor vehicles and aircraft traffic is not required under this Ruling.

Environmental Protection Agency

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III. SOURCES LOCATING IN DESIGNATED CLEAN OR UNCLASSIFIABLE AREAS WHICH WOULD CAUSE OR CONTRIBUTE TO A VIOLATION OF A NATIONAL AMBIENT AIR QUALITY STANDARD

A. This section applies only to major sources or major modifications which would

locate in an area designated in 40 CFR 81.300 *et seq.* as attainment or unclassifiable in a State where EPA has not yet approved the State preconstruction review program required by 40 CFR 51.165(b), if the source or modification would exceed the following significance levels at any locality that does not meet the NAAQS:

| Pollutant | Annual | Averaging time (hours) | | | |
|-----------------------|-----------------------------|---------------------------|-----------------------------|----------------------------|-----------------------|
| | | 24 | 8 | 3 | 1 |
| SO ₂ | 1.0 µg/m ³ | 5 µg/m ³ ..... | ..... | 25 µg/m ³ | 2 mg/m ³ . |
| TSP | 1.0 µg/m ³ | 5 µg/m ³ ..... | ..... | ..... |  |
| NO ₂ | 1.0 µg/m ³ ..... | ..... | ..... | ..... |  |
| CO ..... | ..... | ..... | 0.5 mg/m ³ ..... | ..... |  |

B. Sources to which this section applies must meet Conditions 1, 2, and 4 of Section IV.A. of this ruling.² However, such sources may be exempt from Condition 3 of Section IV.A. of this ruling.

C. *Review of specified sources for air quality impact.* For stable air pollutants (i.e. SO₂, particulate matter and CO), the determination of whether a source will cause or contribute to a violation of an NAAQS generally should be made on a case-by-case basis as of the proposed new source's start-up date using the source's allowable emissions in an atmospheric simulation model (unless a source will clearly impact on a receptor which exceeds an NAAQS).

For sources of nitrogen oxides, the initial determination of whether a source would cause or contribute to a violation of the NAAQS for NO₂ should be made using an atmospheric simulation model assuming all the nitric oxide emitted is oxidized to NO₂ by the time the plume reaches ground level. The initial concentration estimates may be adjusted if adequate data are available to account for the expected oxidation rate.

For ozone, sources of volatile organic compounds, locating outside a designated ozone nonattainment area, will be presumed to have no significant impact on the designated nonattainment area. If ambient monitoring indicates that the area of source location is in fact nonattainment, then the source may be permitted under the provisions of any State plan adopted pursuant to section 110(a)(2)(D) of the Act until the area is designated nonattainment and a State Implementation Plan revision is approved. If no State plan pursuant to section 110(a)(2)(D) has been adopted and approved, then this Ruling shall apply.

As noted above, the determination as to whether a source would cause or contribute to a violation of an NAAQS should be made

as of the new source's start-up date. Therefore, if a designated nonattainment area is projected to be an attainment area as part of an approved SIP control strategy by the new source start-up date, offsets would not be required if the new source would not cause a new violation.

D. *Sources locating in clean areas*, but would cause a new violating of an NAAQS. If the reviewing authority finds that the emissions from a proposed source would cause a new violation of an NAAQS, but would not contribute to an existing violation, approval may be granted only if both of the following conditions are met:

Condition 1. The new source is required to meet a more stringent emission limitation³ and/or the control of existing sources below allowable levels is required so that the source will not cause a violation of any NAAQS.

³If the reviewing authority determines that technological or economic limitations on the application of measurement methodology to a particular class of sources would make the imposition of an enforceable numerical emission standard infeasible, the authority may instead prescribe a design, operational or equipment standard. In such cases, the reviewing authority shall make its best estimate as to the emission rate that will be achieved and must specify that rate in the required submission to EPA (see Part V). Any permits issued without an enforceable numerical emission standard must contain enforceable conditions which assure that the design characteristics or equipment will be properly maintained (or that the operational conditions will be properly performed) so as to continuously achieve the assumed degree of control. Such conditions shall be enforceable as emission limitations by private parties under section 304. Hereafter, the term *emission limitation* shall also include such design, operational, or equipment standards.

²The discussion in this paragraph is a proposal, but represents EPA's interim policy until final rulemaking is completed.

Condition 2. The new emission limitations for the new source as well as any existing sources affected must be enforceable in accordance with the mechanisms set forth in Section V of this appendix.

IV. SOURCES THAT WOULD LOCATE IN A DESIGNATED NONATTAINMENT AREA

A. *Conditions for approval.* If the reviewing authority finds that the major stationary source or major modification would be constructed in an area designated in 40 CFR 81.300 *et seq* as nonattainment for a pollutant for which the stationary source or modification is major, approval may be granted only if the following conditions are met:

Condition 1. The new source is required to meet an emission Limitation⁴ which specifies the lowest achievable emission rate for such source.

Condition 2. The applicant must certify that all existing major sources owned or operated by the applicant (or any entity controlling, controlled by, or under common control with the applicant) in the same State as the proposed source are in compliance with all applicable emission limitations and standards under the Act (or are in compliance with an expeditious schedule which is Federally enforceable or contained in a court decree).

Condition 3. Emission reductions (*offsets*) from existing sources⁵ in the area of the proposed source (whether or not under the same ownership) are required such that there will

be reasonable progress toward attainment of the applicable NAAQS.⁶

Only intrapollutant emission offsets will be acceptable (e.g., hydrocarbon increases may not be offset against SO₂ reductions).

Condition 4. The emission offsets will provide a positive net air quality benefit in the affected area (see Section IV.D. below). Atmospheric simulation modeling is not necessary for volatile organic compounds and NO_x. Fulfillment of Condition 3 and Section IV.D. will be considered adequate to meet this condition.

B. *Exemptions from certain conditions.* The reviewing authority may exempt the following sources from Condition 1 under Section III or Conditions 3 and 4. Section IV.A.:

(i) Resource recovery facilities burning municipal solid waste, and (ii) sources which must switch fuels due to lack of adequate fuel supplies or where a source is required to be modified as a result of EPA regulations (e.g., lead-in-fuel requirements) and no exemption from such regulation is available to the source. Such an exemption may be granted only if:

1. The applicant demonstrates that it made its best efforts to obtain sufficient emission offsets to comply with Condition 1 under Section III or Conditions 3 and 4 under Section IV.A. and that such efforts were unsuccessful;

2. The applicant has secured all available emission offsets; and

3. The applicant will continue to seek the necessary emission offsets and apply them when they become available.

Such an exemption may result in the need to revise the SIP to provide additional control of existing sources.

Temporary emission sources, such as pilot plants, portable facilities which will be relocated outside of the nonattainment area after a short period of time, and emissions resulting from the construction phase of a new source, are exempt from Conditions 3 and 4 of this section.

C. *Baseline for determining credit for emission and air quality offsets.* The baseline for determining credit for emission and air quality offsets will be the SIP emission limitations in effect at the time the application to construct or modify a source is filed. Thus, credit for emission offset purposes may be allowable for existing control that goes beyond that required by the SIP. Emission offsets generally should be made on a pounds per hour basis when all facilities involved in the emission offset calculations are operating at their maximum expected or allowed production rate. The reviewing agency should specify other averaging periods (e.g., tons per

⁴If the reviewing authority determines that technological or economic limitations on the application of measurement methodology to a particular class of sources would make the imposition of an enforceable numerical emission standard infeasible, the authority may instead prescribe a design, operational or equipment standard. In such cases, the reviewing authority shall make its best estimate as to the emission rate that will be achieved and must specify that rate in the required submission to EPA (see Part V). Any permits issued without an enforceable numerical emission standard must contain enforceable conditions which assure that the design characteristics or equipment will be properly maintained (or that the operational conditions will be properly performed) so as to continuously achieve the assumed degree of control. Such conditions shall be enforceable as emission limitations by private parties under section 304. Hereafter, the term *emission limitation* shall also include such design, operational, or equipment standards.

⁵Subject to the provisions of section IV.C. below.

⁶The discussion in this paragraph is a proposal, but represents EPA's interim policy until final rulemaking is completed.

year) in addition to the pounds per hour basis if necessary to carry out the intent of this Ruling. When offsets are calculated on a tons per year basis, the baseline emissions for existing sources providing the offsets should be calculated using the actual annual operating hours for the previous one or two year period (or other appropriate period if warranted by cyclical business conditions). Where the SIP requires certain hardware controls in lieu of an emission limitation (e.g., floating roof tanks for petroleum storage), baseline allowable emissions should be based on actual operating conditions for the previous one or two year period (i.e., actual throughput and vapor pressures) in conjunction with the required hardware controls.

1. *No meaningful or applicable SIP requirement.* Where the applicable SIP does not contain an emission limitation for a source or source category, the emission offset baseline involving such sources shall be the actual emissions determined in accordance with the discussion above regarding operating conditions.

Where the SIP emission limit allows greater emissions than the uncontrolled emission rate of the source (as when a State has a single particulate emission limit for all fuels), emission offset credit will be allowed only for control below the uncontrolled emission rate.

2. *Combustion of fuels.* Generally, the emissions for determining emission offset credit involving an existing fuel combustion source will be the allowable emissions under the SIP for the type of fuel being burned at the time the new source application is filed (i.e., if the existing source has switched to a different type of fuel at some earlier date, any resulting emission reduction [either actual or allowable] shall not be used for emission offset credit). If the existing source commits to switch to a cleaner fuel at some future date, emission offset credit based on the allowable emissions for the fuels involved is not acceptable unless the permit is conditioned to require the use of a specified alternative control measure which would achieve the same degree of emission reduction should the source switch back to a dirtier fuel at some later date. The reviewing authority should ensure that adequate long-term supplies of the new fuel are available before granting emission offset credit for fuel switches.

3. *Emission Reduction Credits from Shutdowns and Curtailments.*

(i) Emissions reductions achieved by shutting down an existing source or curtailing production or operating hours may be generally credited for offsets if they meet the requirements in paragraphs IV.C.3.i.1. through 2 of this section.

(1) Such reductions are surplus, permanent, quantifiable, and federally enforceable.

(2) The shutdown or curtailment occurred after the last day of the base year for the SIP planning process. For purposes of this paragraph, a reviewing authority may choose to consider a prior shutdown or curtailment to have occurred after the last day of the base year if the projected emissions inventory used to develop the attainment demonstration explicitly includes the emissions from such previously shutdown or curtailed emission units. However, in no event may credit be given for shutdowns that occurred before August 7, 1977.

(ii) Emissions reductions achieved by shutting down an existing source or curtailing production or operating hours and that do not meet the requirements in paragraphs IV.C.3.i.1. through 2 of this section may be generally credited only if:

(1) The shutdown or curtailment occurred on or after the date the new source permit application is filed; or

(2) The applicant can establish that the proposed new source is a replacement for the shutdown or curtailed source, and the emissions reductions achieved by the shutdown or curtailment met the requirements of paragraphs IV.C.3.i.1. through 2 of this section.

4. *Credit for VOC substitution.* As set forth in the Agency's "Recommended Policy on Control of Volatile Organic Compounds" (42 FR 35314, July 8, 1977), EPA has found that almost all non-methane VOCs are photochemically reactive and that low reactivity VOCs eventually form as much ozone as the highly reactive VOCs. Therefore, no emission offset credit may be allowed for replacing one VOC compound with another of lesser reactivity, except for those compounds listed in Table 1 of the above policy statement.

5. *"Banking" of emission offset credit.* For new sources obtaining permits by applying offsets after January 16, 1979, the reviewing authority may allow offsets that exceed the requirements of reasonable progress toward attainment (Condition 3) to be "banked" (i.e., saved to provide offsets for a source seeking a permit in the future) for use under this Ruling. Likewise, the reviewing authority may allow the owner of an existing source that reduces its own emissions to bank any resulting reductions beyond those required by the SIP for use under this Ruling, even if none of the offsets are applied immediately to a new source permit. A reviewing authority may allow these banked offsets to be used under the preconstruction review program required by Part D, as long as these banked emissions are identified and accounted for in the SIP control strategy. A reviewing authority may not approve the construction of a source using banked offsets if the new source would interfere with the SIP control strategy or if such use would violate any other condition set forth for use

of offsets. To preserve banked offsets, the reviewing authority should identify them in either a SIP revision or a permit, and establish rules as to how and when they may be used.

6. *Offset credit for meeting NSPS or NESHAPS.* Where a source is subject to an emission limitation established in a New Source Performance Standard (NSPS) or a National Emission Standard for Hazardous Air Pollutants (NESHAPS), (*i.e.*, requirements under sections 111 and 112, respectively, of the Act), and a different SIP limitation, the more stringent limitation shall be used as the baseline for determining credit for emission and air quality offsets. The difference in emissions between the SIP and the NSPS or NESHAPS, for such source may not be used as offset credit. However, if a source were not subject to an NSPS or NESHAPS, for example if its construction had commenced prior to the proposal of an NSPS or NESHAPS for that source category, offset credit can be permitted for tightening the SIP to the NSPS or NESHAPS level for such source.

D. *Location of offsetting emissions.* The owner or operator of a new or modified major stationary source may comply with any offset requirement in effect under this Ruling for increased emissions of any air pollutant only by obtaining emissions reductions of such air pollutant from the same source or other sources in the same nonattainment area, except that the reviewing authority may allow the owner or operator of a source to obtain such emissions reductions in another nonattainment area if the conditions in IV.D.1 and 2 are met.

1. The other area has an equal or higher nonattainment classification than the area in which the source is located.

2. Emissions from such other area contribute to a violation of the national ambient air quality standard in the nonattainment area in which the source is located.

E. *Reasonable further progress.* Permits to construct and operate may be issued if the reviewing authority determines that, by the time the source is to commence operation, sufficient offsetting emissions reductions have been obtained, such that total allowable emissions from existing sources in the region, from new or modified sources which are not major emitting facilities, and from the proposed source will be sufficiently less than total emissions from existing sources prior to the application for such permit to construct or modify so as to represent (when considered together with the plan provisions required under CAA section 172) reasonable further progress (as defined in CAA section 171).

F. *Source obligation.* At such time that a particular source or modification becomes a major stationary source or major modification solely by virtue of a relaxation in any enforceable limitation which was established

after August 7, 1980, on the capacity of the source or modification otherwise to emit a pollutant, such as a restriction on hours of operation, then the requirements of this Ruling shall apply to the source or modification as though construction had not yet commenced on the source or modification.

G. *Offset Ratios.* 1. In meeting the emissions offset requirements of paragraph IV.A, Condition 3 of this Ruling for ozone nonattainment areas that are subject to subpart 2, part D, title I of the Act, the ratio of total actual emissions reductions of VOC to the emissions increase of VOC shall be as follows:

(i) In any marginal nonattainment area for ozone—at least 1.1:1;

(ii) In any moderate nonattainment area for ozone—at least 1.15:1;

(iii) In any serious nonattainment area for ozone—at least 1.2:1;

(iv) In any severe nonattainment area for ozone—at least 1.3:1 (except that the ratio may be at least 1.2:1 if the State also requires all existing major sources in such nonattainment area to use BACT for the control of VOC); and

(v) In any extreme nonattainment area for ozone—at least 1.5:1 (except that the ratio may be at least 1.2:1 if the State also requires all existing major sources in such nonattainment area to use BACT for the control of VOC); and

2. Notwithstanding the requirements of paragraph IV.G.1 of this Ruling for meeting the requirements of paragraph IV.A, Condition 3 of this Ruling, the ratio of total actual emissions reductions of VOC to the emissions increase of VOC shall be at least 1.15:1 for all areas within an ozone transport region that is subject to subpart 2, part D, title I of the Act, except for serious, severe, and extreme ozone nonattainment areas that are subject to subpart 2, part D, title I of the Act.

3. In meeting the emissions offset requirements of paragraph IV.A, Condition 3 of this Ruling for ozone nonattainment areas that are subject to subpart 1, part D, title I of the Act (but are not subject to subpart 2, part D, title I of the Act, including 8-hour ozone nonattainment areas subject to 40 CFR 51.902(b)), the ratio of total actual emissions reductions of VOC to the emissions increase of VOC shall be at least 1:1.

H. *Additional provisions for emissions of nitrogen oxides in ozone transport regions and nonattainment areas.* The requirements of this Ruling applicable to major stationary sources and major modifications of volatile organic compounds shall apply to nitrogen oxides emissions from major stationary sources and major modifications of nitrogen oxides in an ozone transport region or in any ozone nonattainment area, except in ozone nonattainment areas where the Administrator has granted a NO_x waiver applying

the standards set forth under 182(f) and the waiver continues to apply.

I. Applicability procedures.

1. To determine whether a project constitutes a major modification, the reviewing authority shall apply the principles set out in paragraphs IV.I.1(i) through (v) of this Ruling.

(i) Except as otherwise provided in paragraph IV.I.2 of this Ruling, and consistent with the definition of major modification contained in paragraph II.A.5 of this Ruling, a project is a major modification for a regulated NSR pollutant if it causes two types of emissions increases—a significant emissions increase (as defined in paragraph II.A.23 of this Ruling), and a significant net emissions increase (as defined in paragraphs II.A.6 and 10 of this Ruling). The project is not a major modification if it does not cause a significant emissions increase. If the project causes a significant emissions increase, then the project is a major modification only if it also results in a significant net emissions increase.

(ii) The procedure for calculating (before beginning actual construction) whether a significant emissions increase (i.e., the first step of the process) will occur depends upon the type of emissions units being modified, according to paragraphs IV.I.1(iii) through (v) of this Ruling. The procedure for calculating (before beginning actual construction) whether a significant net emissions increase will occur at the major stationary source (i.e., the second step of the process) is contained in the definition in paragraph II.A.6 of this Ruling. Regardless of any such preconstruction projections, a major modification results if the project causes a significant emissions increase and a significant net emissions increase.

(iii) *Actual-to-projected-actual applicability test for projects that only involve existing emissions units.* A significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the difference between the projected actual emissions (as defined in paragraph II.A.24 of this Ruling) and the baseline actual emissions (as defined in paragraphs II.A.30(i) and (ii) of this Ruling, as applicable), for each existing emissions unit, equals or exceeds the significant amount for that pollutant (as defined in paragraph II.A.10 of this Ruling).

(iv) *Actual-to-potential test for projects that only involve construction of a new emissions unit(s).* A significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the difference between the potential to emit (as defined in paragraph II.A.3 of this Ruling) from each new emissions unit following completion of the project and the baseline actual emissions (as defined in paragraph II.A.30(iii) of this Ruling) of these units before the project equals or exceeds the significant amount for that

pollutant (as defined in paragraph II.A.10 of this Ruling).

(v) *Hybrid test for projects that involve multiple types of emissions units.* A significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the emissions increases for each emissions unit, using the method specified in paragraphs IV.I.1(iii) through (iv) of this Ruling as applicable with respect to each emissions unit, for each type of emissions unit equals or exceeds the significant amount for that pollutant (as defined in paragraph II.A.10 of this Ruling).

2. For any major stationary source for a PAL for a regulated NSR pollutant, the major stationary source shall comply with requirements under paragraph IV.K of this Ruling.

J. Provisions for projected actual emissions. The provisions of this paragraph IV.J apply to projects at existing emissions units at a major stationary source (other than projects at a source with a PAL) in circumstances where there is a reasonable possibility that a project that is not a part of a major modification may result in a significant emissions increase and the owner or operator elects to use the method specified in paragraphs II.A.24(ii)(a) through (c) of this Ruling for calculating projected actual emissions.

1. Before beginning actual construction of the project, the owner or operator shall document and maintain a record of the following information:

- (i) A description of the project;
- (ii) Identification of the emissions unit(s) whose emissions of a regulated NSR pollutant could be affected by the project; and
- (iii) A description of the applicability test used to determine that the project is not a major modification for any regulated NSR pollutant, including the baseline actual emissions, the projected actual emissions, the amount of emissions excluded under paragraph II.A.24(ii)(c) of this Ruling and an explanation for why such amount was excluded, and any netting calculations, if applicable.

2. If the emissions unit is an existing electric utility steam generating unit, before beginning actual construction, the owner or operator shall provide a copy of the information set out in paragraph IV.J.1 of this Ruling to the reviewing authority. Nothing in this paragraph IV.J.2 shall be construed to require the owner or operator of such a unit to obtain any determination from the reviewing authority before beginning actual construction.

3. The owner or operator shall monitor the emissions of any regulated NSR pollutant that could increase as a result of the project and that is emitted by any emissions units identified in paragraph IV.J.1(ii) of this Ruling; and calculate and maintain a record of the annual emissions, in tons per year on a

calendar year basis, for a period of 5 years following resumption of regular operations after the change, or for a period of 10 years following resumption of regular operations after the change if the project increases the design capacity or potential to emit of that regulated NSR pollutant at such emissions unit.

4. If the unit is an existing electric utility steam generating unit, the owner or operator shall submit a report to the reviewing authority within 60 days after the end of each year, during which records must be generated under paragraph IV.J.3 of this Ruling setting out the unit's annual emissions during the year that preceded submission of the report.

5. If the unit is an existing unit other than an electric utility steam generating unit, the owner or operator shall submit a report to the reviewing authority if the annual emissions, in tons per year, from the project identified in paragraph IV.J.1 of this Ruling, exceed the baseline actual emissions (as documented and maintained pursuant to paragraph IV.J.1(iii) of this Ruling) by a significant amount (as defined in paragraph II.A.10 of this Ruling) for that regulated NSR pollutant, and if such emissions differ from the preconstruction projection as documented and maintained pursuant to paragraph IV.J.1(iii) of this Ruling. Such report shall be submitted to the reviewing authority within 60 days after the end of such year. The report shall contain the following:

- (i) The name, address and telephone number of the major stationary source;
- (ii) The annual emissions as calculated pursuant to paragraph IV.J.3 of this Ruling; and
- (iii) Any other information that the owner or operator wishes to include in the report (e.g., an explanation as to why the emissions differ from the preconstruction projection).

6. [Reserved]

7. The owner or operator of the source shall make the information required to be documented and maintained pursuant to this paragraph IV.J of this Ruling available for review upon a request for inspection by the reviewing authority or the general public pursuant to the requirements contained in §70.4(b)(3)(viii) of this chapter.

K. *Actuals PALs.* The provisions in paragraphs IV.K.1 through 15 of this Ruling govern actuals PALs.

1. *Applicability.*

(i) The reviewing authority may approve the use of an actuals PAL for any existing major stationary source (except as provided in paragraph IV.K.1(ii) of this Ruling) if the PAL meets the requirements in paragraphs IV.K.1 through 15 of this Ruling. The term "PAL" shall mean "actuals PAL" throughout paragraph IV.K of this Ruling.

(ii) The reviewing authority shall not allow an actuals PAL for VOC or NO_x for any

major stationary source located in an extreme ozone nonattainment area.

(iii) Any physical change in or change in the method of operation of a major stationary source that maintains its total source-wide emissions below the PAL level, meets the requirements in paragraphs IV.K.1 through 15 of this Ruling, and complies with the PAL permit:

(a) Is not a major modification for the PAL pollutant;

(b) Does not have to be approved through a nonattainment major NSR program; and

(c) Is not subject to the provisions in paragraph IV.F of this Ruling (restrictions on relaxing enforceable emission limitations that the major stationary source used to avoid applicability of a nonattainment major NSR program).

(iv) Except as provided under paragraph IV.K.1(iii)(c) of this Ruling, a major stationary source shall continue to comply with all applicable Federal or State requirements, emission limitations, and work practice requirements that were established prior to the effective date of the PAL.

2. *Definitions.* For the purposes of this paragraph IV.K, the definitions in paragraphs IV.K.2(i) through (xi) of this Ruling apply. When a term is not defined in these paragraphs, it shall have the meaning given in paragraph II.A of this Ruling or in the Act.

(i) *Actuals PAL* for a major stationary source means a PAL based on the baseline actual emissions (as defined in paragraph II.A.30 of this Ruling) of all emissions units (as defined in paragraph II.A.7 of this Ruling) at the source, that emit or have the potential to emit the PAL pollutant.

(ii) *Allowable emissions* means "allowable emissions" as defined in paragraph II.A.11 of this Ruling, except as this definition is modified according to paragraphs IV.K.2(ii)(a) through (b) of this Ruling.

(a) The allowable emissions for any emissions unit shall be calculated considering any emission limitations that are enforceable as a practical matter on the emissions unit's potential to emit.

(b) An emissions unit's potential to emit shall be determined using the definition in paragraph II.A.3 of this Ruling, except that the words "enforceable as a practical matter" should be added after "federally enforceable."

(iii) *Small emissions unit* means an emissions unit that emits or has the potential to emit the PAL pollutant in an amount less than the significant level for that PAL pollutant, as defined in paragraph II.A.10 of this Ruling or in the Act, whichever is lower.

(iv) *Major emissions unit* means:

(a) Any emissions unit that emits or has the potential to emit 100 tons per year or more of the PAL pollutant in an attainment area; or

(b) Any emissions unit that emits or has the potential to emit the PAL pollutant in an amount that is equal to or greater than the major source threshold for the PAL pollutant as defined by the Act for nonattainment areas. For example, in accordance with the definition of major stationary source in section 182(c) of the Act, an emissions unit would be a major emissions unit for VOC if the emissions unit is located in a serious ozone nonattainment area and it emits or has the potential to emit 50 or more tons of VOC per year.

(v) *Plantwide applicability limitation (PAL)* means an emission limitation expressed in tons per year, for a pollutant at a major stationary source, that is enforceable as a practical matter and established source-wide in accordance with paragraphs IV.K.1 through 15 of this Ruling.

(vi) *PAL effective date* generally means the date of issuance of the PAL permit. However, the PAL effective date for an increased PAL is the date any emissions unit which is part of the PAL major modification becomes operational and begins to emit the PAL pollutant.

(vii) *PAL effective period* means the period beginning with the PAL effective date and ending 10 years later.

(viii) *PAL major modification* means, notwithstanding paragraphs II.A.5 and 6 of this Ruling (the definitions for major modification and net emissions increase), any physical change in or change in the method of operation of the PAL source that causes it to emit the PAL pollutant at a level equal to or greater than the PAL.

(ix) *PAL permit* means the permit issued under this Ruling, the major NSR permit, the minor NSR permit, or the State operating permit under a program that is approved into the plan, or the title V permit issued by the reviewing authority that establishes a PAL for a major stationary source.

(x) *PAL pollutant* means the pollutant for which a PAL is established at a major stationary source.

(xi) *Significant emissions unit* means an emissions unit that emits or has the potential to emit a PAL pollutant in an amount that is equal to or greater than the significant level (as defined in paragraph II.A.10 of this Ruling or in the Act, whichever is lower) for that PAL pollutant, but less than the amount that would qualify the unit as a major emissions unit as defined in paragraph IV.K.2(iv) of this Ruling.

3. *Permit application requirements.* As part of a permit application requesting a PAL, the owner or operator of a major stationary source shall submit the following information to the reviewing authority for approval:

(i) A list of all emissions units at the source designated as small, significant or major based on their potential to emit. In addition, the owner or operator of the source

shall indicate which, if any, Federal or State applicable requirements, emission limitations or work practices apply to each unit.

(ii) Calculations of the baseline actual emissions (with supporting documentation). Baseline actual emissions are to include emissions associated not only with operation of the unit, but also emissions associated with startup, shutdown and malfunction.

(iii) The calculation procedures that the major stationary source owner or operator proposes to use to convert the monitoring system data to monthly emissions and annual emissions based on a 12-month rolling total for each month as required by paragraph IV.K.13(i) of this Ruling.

4. General requirements for establishing PALs.

(i) The reviewing authority is allowed to establish a PAL at a major stationary source, provided that at a minimum, the requirements in paragraphs IV.K.4(i) (a) through (g) of this Ruling are met.

(a) The PAL shall impose an annual emission limitation in tons per year, that is enforceable as a practical matter, for the entire major stationary source. For each month during the PAL effective period after the first 12 months of establishing a PAL, the major stationary source owner or operator shall show that the sum of the monthly emissions from each emissions unit under the PAL for the previous 12 consecutive months is less than the PAL (a 12-month average, rolled monthly). For each month during the first 11 months from the PAL effective date, the major stationary source owner or operator shall show that the sum of the preceding monthly emissions from the PAL effective date for each emissions unit under the PAL is less than the PAL.

(b) The PAL shall be established in a PAL permit that meets the public participation requirements in paragraph IV.K.5 of this Ruling.

(c) The PAL permit shall contain all the requirements of paragraph IV.K.7 of this Ruling.

(d) The PAL shall include fugitive emissions, to the extent quantifiable, from all emissions units that emit or have the potential to emit the PAL pollutant at the major stationary source.

(e) Each PAL shall regulate emissions of only one pollutant.

(f) Each PAL shall have a PAL effective period of 10 years.

(g) The owner or operator of the major stationary source with a PAL shall comply with the monitoring, recordkeeping, and reporting requirements provided in paragraphs IV.K. 12 through 14 of this Ruling for each emissions unit under the PAL through the PAL effective period.

(ii) At no time (during or after the PAL effective period) are emissions reductions of a PAL pollutant, which occur during the PAL

effective period, creditable as decreases for purposes of offsets under paragraph IV.C of this Ruling unless the level of the PAL is reduced by the amount of such emissions reductions and such reductions would be creditable in the absence of the PAL.

5. *Public participation requirement for PALs.* PALs for existing major stationary sources shall be established, renewed, or increased through a procedure that is consistent with ((51.160 and 51.161 of this chapter. This includes the requirement that the reviewing authority provide the public with notice of the proposed approval of a PAL permit and at least a 30-day period for submittal of public comment. The reviewing authority must address all material comments before taking final action on the permit.

6. *Setting the 10-year actuals PAL level.* The actuals PAL level for a major stationary source shall be established as the sum of the baseline actual emissions (as defined in paragraph II.A.30 of this Ruling) of the PAL pollutant for each emissions unit at the source; plus an amount equal to the applicable significant level for the PAL pollutant under paragraph II.A.10 of this Ruling or under the Act, whichever is lower. When establishing the actuals PAL level, for a PAL pollutant, only one consecutive 24-month period must be used to determine the baseline actual emissions for all existing emissions units. However, a different consecutive 24-month period may be used for each different PAL pollutant. Emissions associated with units that were permanently shut down after this 24-month period must be subtracted from the PAL level. Emissions from units on which actual construction began after the 24-month period must be added to the PAL level in an amount equal to the potential to emit of the units. The reviewing authority shall specify a reduced PAL level(s) (in tons/yr) in the PAL permit to become effective on the future compliance date(s) of any applicable Federal or State regulatory requirement(s) that the reviewing authority is aware of prior to issuance of the PAL permit. For instance, if the source owner or operator will be required to reduce emissions from industrial boilers in half from baseline emissions of 60 ppm NO_x to a new rule limit of 30 ppm, then the permit shall contain a future effective PAL level that is equal to the current PAL level reduced by half of the original baseline emissions of such unit(s).

7. *Contents of the PAL permit.* The PAL permit contain, at a minimum, the information in paragraphs IV.K.7 (i) through (x) of this Ruling.

(i) The PAL pollutant and the applicable source-wide emission limitation in tons per year.

(ii) The PAL permit effective date and the expiration date of the PAL (PAL effective period).

(iii) Specification in the PAL permit that if a major stationary source owner or operator applies to renew a PAL in accordance with paragraph IV.K.10 of this Ruling before the end of the PAL effective period, then the PAL shall not expire at the end of the PAL effective period. It shall remain in effect until a revised PAL permit is issued by the reviewing authority.

(iv) A requirement that emission calculations for compliance purposes include emissions from startups, shutdowns and malfunctions.

(v) A requirement that, once the PAL expires, the major stationary source is subject to the requirements of paragraph IV.K.9 of this Ruling.

(vi) The calculation procedures that the major stationary source owner or operator shall use to convert the monitoring system data to monthly emissions and annual emissions based on a 12-month rolling total for each month as required by paragraph IV.K.13(i) of this Ruling.

(vii) A requirement that the major stationary source owner or operator monitor all emissions units in accordance with the provisions under paragraph IV.K.12 of this Ruling.

(viii) A requirement to retain the records required under paragraph IV.K.13 of this Ruling on site. Such records may be retained in an electronic format.

(ix) A requirement to submit the reports required under paragraph IV.K.14 of this Ruling by the required deadlines.

(x) Any other requirements that the reviewing authority deems necessary to implement and enforce the PAL.

8. *PAL effective period and reopening of the PAL permit.* The requirements in paragraphs IV.K.8(i) and (ii) of this Ruling apply to actuals PALs.

(i) *PAL effective period.* The reviewing authority shall specify a PAL effective period of 10 years.

(ii) *Reopening of the PAL permit.*

(a) During the PAL effective period, the reviewing authority must reopen the PAL permit to:

(1) Correct typographical/calculation errors made in setting the PAL or reflect a more accurate determination of emissions used to establish the PAL.

(2) Reduce the PAL if the owner or operator of the major stationary source creates creditable emissions reductions for use as offsets under paragraph IV.C of this Ruling.

(3) Revise the PAL to reflect an increase in the PAL as provided under paragraph IV.K.11 of this Ruling.

(b) The reviewing authority shall have discretion to reopen the PAL permit for the following:

(1) Reduce the PAL to reflect newly applicable Federal requirements (for example,

NSPS) with compliance dates after the PAL effective date.

(2) Reduce the PAL consistent with any other requirement, that is enforceable as a practical matter, and that the State may impose on the major stationary source under the plan.

(3) Reduce the PAL if the reviewing authority determines that a reduction is necessary to avoid causing or contributing to a NAAQS or PSD increment violation, or to an adverse impact on an air quality related value that has been identified for a Federal Class I area by a Federal Land Manager and for which information is available to the general public.

(c) Except for the permit reopening in paragraph IV.K.8(ii)(a)(1) of this Ruling for the correction of typographical/calculation errors that do not increase the PAL level, all other reopenings shall be carried out in accordance with the public participation requirements of paragraph IV.K.5 of this Ruling.

9. *Expiration of a PAL.* Any PAL which is not renewed in accordance with the procedures in paragraph IV.K.10 of this Ruling shall expire at the end of the PAL effective period, and the requirements in paragraphs IV.K.9(i) through (v) of this Ruling shall apply.

(i) Each emissions unit (or each group of emissions units) that existed under the PAL shall comply with an allowable emission limitation under a revised permit established according to the procedures in paragraphs IV.K.9(i)(a) through (b) of this Ruling.

(a) Within the time frame specified for PAL renewals in paragraph IV.K.10(ii) of this Ruling, the major stationary source shall submit a proposed allowable emission limitation for each emissions unit (or each group of emissions units, if such a distribution is more appropriate as decided by the reviewing authority) by distributing the PAL allowable emissions for the major stationary source among each of the emissions units that existed under the PAL. If the PAL had not yet been adjusted for an applicable requirement that became effective during the PAL effective period, as required under paragraph IV.K.10(v) of this Ruling, such distribution shall be made as if the PAL had been adjusted.

(b) The reviewing authority shall decide whether and how the PAL allowable emissions will be distributed and issue a revised permit incorporating allowable limits for each emissions unit, or each group of emissions units, as the reviewing authority determines is appropriate.

(ii) Each emissions unit(s) shall comply with the allowable emission limitation on a 12-month rolling basis. The reviewing authority may approve the use of monitoring systems (source testing, emission factors, etc.) other than CEMS, CERMS, PEMS or

CPMS to demonstrate compliance with the allowable emission limitation.

(iii) Until the reviewing authority issues the revised permit incorporating allowable limits for each emissions unit, or each group of emissions units, as required under paragraph IV.K.9(i)(a) of this Ruling, the source shall continue to comply with a source-wide, multi-unit emissions cap equivalent to the level of the PAL emission limitation.

(iv) Any physical change or change in the method of operation at the major stationary source will be subject to the nonattainment major NSR requirements if such change meets the definition of major modification in paragraph II.A.5 of this Ruling.

(v) The major stationary source owner or operator shall continue to comply with any State or Federal applicable requirements (BACT, RACT, NSPS, etc.) that may have applied either during the PAL effective period or prior to the PAL effective period except for those emission limitations that had been established pursuant to paragraph IV.F of this Ruling, but were eliminated by the PAL in accordance with the provisions in paragraph IV.K.1(iii)(c) of this Ruling.

10. Renewal of a PAL.

(i) The reviewing authority shall follow the procedures specified in paragraph IV.K.5 of this Ruling in approving any request to renew a PAL for a major stationary source, and shall provide both the proposed PAL level and a written rationale for the proposed PAL level to the public for review and comment. During such public review, any person may propose a PAL level for the source for consideration by the reviewing authority.

(ii) *Application deadline.* The major stationary source owner or operator shall submit a timely application to the reviewing authority to request renewal of a PAL. A timely application is one that is submitted at least 6 months prior to, but not earlier than 18 months from, the date of permit expiration. This deadline for application submittal is to ensure that the permit will not expire before the permit is renewed. If the owner or operator of a major stationary source submits a complete application to renew the PAL within this time period, then the PAL shall continue to be effective until the revised permit with the renewed PAL is issued.

(iii) *Application requirements.* The application to renew a PAL permit shall contain the information required in paragraphs IV.K.10(iii)(a) through (d) of this Ruling.

(a) The information required in paragraphs IV.K.3(i) through (iii) of this Ruling.

(b) A proposed PAL level.

(c) The sum of the potential to emit of all emissions units under the PAL (with supporting documentation).

(d) Any other information the owner or operator wishes the reviewing authority to

consider in determining the appropriate level for renewing the PAL.

(iv) *PAL adjustment.* In determining whether and how to adjust the PAL, the reviewing authority shall consider the options outlined in paragraphs IV.K.10(iv)(a) and (b) of this Ruling. However, in no case may any such adjustment fail to comply with paragraph IV.K.10(iv)(c) of this Ruling.

(a) If the emissions level calculated in accordance with paragraph IV.K.6 of this Ruling is equal to or greater than 80 percent of the PAL level, the reviewing authority may renew the PAL at the same level without considering the factors set forth in paragraph IV.K.10(iv)(b) of this Ruling; or

(b) The reviewing authority may set the PAL at a level that it determines to be more representative of the source's baseline actual emissions, or that it determines to be appropriate considering air quality needs, advances in control technology, anticipated economic growth in the area, desire to reward or encourage the source's voluntary emissions reductions, or other factors as specifically identified by the reviewing authority in its written rationale.

(c) Notwithstanding paragraphs IV.K.10(iv)(a) and (b) of this Ruling,

(1) If the potential to emit of the major stationary source is less than the PAL, the reviewing authority shall adjust the PAL to a level no greater than the potential to emit of the source; and

(2) The reviewing authority shall not approve a renewed PAL level higher than the current PAL, unless the major stationary source has complied with the provisions of paragraph IV.K.11 of this Ruling (increasing a PAL).

(v) If the compliance date for a State or Federal requirement that applies to the PAL source occurs during the PAL effective period, and if the reviewing authority has not already adjusted for such requirement, the PAL shall be adjusted at the time of PAL permit renewal or title V permit renewal, whichever occurs first.

11. Increasing a PAL during the PAL effective period.

(i) The reviewing authority may increase a PAL emission limitation only if the major stationary source complies with the provisions in paragraphs IV.K.11(i)(a) through (d) of this Ruling.

(a) The owner or operator of the major stationary source shall submit a complete application to request an increase in the PAL limit for a PAL major modification. Such application shall identify the emissions unit(s) contributing to the increase in emissions so as to cause the major stationary source's emissions to equal or exceed its PAL.

(b) As part of this application, the major stationary source owner or operator shall demonstrate that the sum of the baseline ac-

tual emissions of the small emissions units, plus the sum of the baseline actual emissions of the significant and major emissions units assuming application of BACT equivalent controls, plus the sum of the allowable emissions of the new or modified emissions unit(s) exceeds the PAL. The level of control that would result from BACT equivalent controls on each significant or major emissions unit shall be determined by conducting a new BACT analysis at the time the application is submitted, unless the emissions unit is currently required to comply with a BACT or LAER requirement that was established within the preceding 10 years. In such a case, the assumed control level for that emissions unit shall be equal to the level of BACT or LAER with which that emissions unit must currently comply.

(c) The owner or operator obtains a major NSR permit for all emissions unit(s) identified in paragraph IV.K.11(i)(a) of this Ruling, regardless of the magnitude of the emissions increase resulting from them (that is, no significant levels apply). These emissions unit(s) shall comply with any emissions requirements resulting from the nonattainment major NSR program process (for example, LAER), even though they have also become subject to the PAL or continue to be subject to the PAL.

(d) The PAL permit shall require that the increased PAL level shall be effective on the day any emissions unit that is part of the PAL major modification becomes operational and begins to emit the PAL pollutant.

(ii) The reviewing authority shall calculate the new PAL as the sum of the allowable emissions for each modified or new emissions unit, plus the sum of the baseline actual emissions of the significant and major emissions units (assuming application of BACT equivalent controls as determined in accordance with paragraph IV.K.11(i)(b)), plus the sum of the baseline actual emissions of the small emissions units.

(iii) The PAL permit shall be revised to reflect the increased PAL level pursuant to the public notice requirements of paragraph IV.K.5 of this Ruling.

12. Monitoring requirements for PALs.

(i) General Requirements.

(a) Each PAL permit must contain enforceable requirements for the monitoring system that accurately determines plantwide emissions of the PAL pollutant in terms of mass per unit of time. Any monitoring system authorized for use in the PAL permit must be based on sound science and meet generally acceptable scientific procedures for data quality and manipulation. Additionally, the information generated by such system must meet minimum legal requirements for admissibility in a judicial proceeding to enforce the PAL permit.

(b) The PAL monitoring system must employ one or more of the four general monitoring approaches meeting the minimum requirements set forth in paragraphs IV.K.12(ii)(a) through (d) of this Ruling and must be approved by the reviewing authority.

(c) Notwithstanding paragraph IV.K.12(i)(b) of this Ruling, you may also employ an alternative monitoring approach that meets paragraph IV.K.12(i)(a) of this Ruling if approved by the reviewing authority.

(d) Failure to use a monitoring system that meets the requirements of this Ruling renders the PAL invalid.

(ii) Minimum Performance Requirements for Approved Monitoring Approaches. The following are acceptable general monitoring approaches when conducted in accordance with the minimum requirements in paragraphs IV.K.12(iii) through (ix) of this Ruling:

(a) Mass balance calculations for activities using coatings or solvents;

(b) CEMS;

(c) CPMS or PEMS; and

(d) Emission Factors.

(iii) Mass Balance Calculations. An owner or operator using mass balance calculations to monitor PAL pollutant emissions from activities using coating or solvents shall meet the following requirements:

(a) Provide a demonstrated means of validating the published content of the PAL pollutant that is contained in or created by all materials used in or at the emissions unit;

(b) Assume that the emissions unit emits all of the PAL pollutant that is contained in or created by any raw material or fuel used in or at the emissions unit, if it cannot otherwise be accounted for in the process; and

(c) Where the vendor of a material or fuel, which is used in or at the emissions unit, publishes a range of pollutant content from such material, the owner or operator must use the highest value of the range to calculate the PAL pollutant emissions unless the reviewing authority determines there is site-specific data or a site-specific monitoring program to support another content within the range.

(iv) CEMS. An owner or operator using CEMS to monitor PAL pollutant emissions shall meet the following requirements:

(a) CEMS must comply with applicable Performance Specifications found in 40 CFR part 60, appendix B; and

(b) CEMS must sample, analyze and record data at least every 15 minutes while the emissions unit is operating.

(v) CPMS or PEMS. An owner or operator using CPMS or PEMS to monitor PAL pollutant emissions shall meet the following requirements:

(a) The CPMS or the PEMS must be based on current site-specific data demonstrating a correlation between the monitored param-

eter(s) and the PAL pollutant emissions across the range of operation of the emissions unit; and

(b) Each CPMS or PEMS must sample, analyze, and record data at least every 15 minutes, or at another less frequent interval approved by the reviewing authority, while the emissions unit is operating.

(vi) Emission factors. An owner or operator using emission factors to monitor PAL pollutant emissions shall meet the following requirements:

(a) All emission factors shall be adjusted, if appropriate, to account for the degree of uncertainty or limitations in the factors' development;

(b) The emissions unit shall operate within the designated range of use for the emission factor, if applicable; and

(c) If technically practicable, the owner or operator of a significant emissions unit that relies on an emission factor to calculate PAL pollutant emissions shall conduct validation testing to determine a site-specific emission factor within 6 months of PAL permit issuance, unless the reviewing authority determines that testing is not required.

(vii) A source owner or operator must record and report maximum potential emissions without considering enforceable emission limitations or operational restrictions for an emissions unit during any period of time that there is no monitoring data, unless another method for determining emissions during such periods is specified in the PAL permit.

(viii) Notwithstanding the requirements in paragraphs IV.K.12(iii) through (vii) of this Ruling, where an owner or operator of an emissions unit cannot demonstrate a correlation between the monitored parameter(s) and the PAL pollutant emissions rate at all operating points of the emissions unit, the reviewing authority shall, at the time of permit issuance:

(a) Establish default value(s) for determining compliance with the PAL based on the highest potential emissions reasonably estimated at such operating point(s); or

(b) Determine that operation of the emissions unit during operating conditions when there is no correlation between monitored parameter(s) and the PAL pollutant emissions is a violation of the PAL.

(ix) Re-validation. All data used to establish the PAL pollutant must be re-validated through performance testing or other scientifically valid means approved by the reviewing authority. Such testing must occur at least once every 5 years after issuance of the PAL.

13. Recordkeeping requirements.

(i) The PAL permit shall require an owner or operator to retain a copy of all records necessary to determine compliance with any requirement of paragraph IV.K of this Ruling and of the PAL, including a determination of

each emissions unit's 12-month rolling total emissions, for 5 years from the date of such record.

(ii) The PAL permit shall require an owner or operator to retain a copy of the following records for the duration of the PAL effective period plus 5 years:

(a) A copy of the PAL permit application and any applications for revisions to the PAL; and

(b) Each annual certification of compliance pursuant to title V and the data relied on in certifying the compliance.

14. *Reporting and notification requirements.* The owner or operator shall submit semi-annual monitoring reports and prompt deviation reports to the reviewing authority in accordance with the applicable title V operating permit program. The reports shall meet the requirements in paragraphs IV.K.14(i) through (iii).

(i) *Semi-Annual Report.* The semi-annual report shall be submitted to the reviewing authority within 30 days of the end of each reporting period. This report shall contain the information required in paragraphs IV.K.14(i)(a) through (g) of this Ruling.

(a) The identification of owner and operator and the permit number.

(b) Total annual emissions (tons/year) based on a 12-month rolling total for each month in the reporting period recorded pursuant to paragraph IV.K.13(i) of this Ruling.

(c) All data relied upon, including, but not limited to, any Quality Assurance or Quality Control data, in calculating the monthly and annual PAL pollutant emissions.

(d) A list of any emissions units modified or added to the major stationary source during the preceding 6-month period.

(e) The number, duration, and cause of any deviations or monitoring malfunctions (other than the time associated with zero and span calibration checks), and any corrective action taken.

(f) A notification of a shutdown of any monitoring system, whether the shutdown was permanent or temporary, the reason for the shutdown, the anticipated date that the monitoring system will be fully operational or replaced with another monitoring system, and whether the emissions unit monitored by the monitoring system continued to operate, and the calculation of the emissions of the pollutant or the number determined by method included in the permit, as provided by paragraph IV.K.12(vii) of this Ruling.

(g) A signed statement by the responsible official (as defined by the applicable title V operating permit program) certifying the truth, accuracy, and completeness of the information provided in the report.

(ii) *Deviation report.* The major stationary source owner or operator shall promptly submit reports of any deviations or exceedance of the PAL requirements, including periods where no monitoring is available. A report

submitted pursuant to §70.6(a)(3)(iii)(B) of this chapter shall satisfy this reporting requirement. The deviation reports shall be submitted within the time limits prescribed by the applicable program implementing §70.6(a)(3)(iii)(B) of this chapter. The reports shall contain the following information:

(a) The identification of owner and operator and the permit number;

(b) The PAL requirement that experienced the deviation or that was exceeded;

(c) Emissions resulting from the deviation or the exceedance; and

(d) A signed statement by the responsible official (as defined by the applicable title V operating permit program) certifying the truth, accuracy, and completeness of the information provided in the report.

(iii) *Re-validation results.* The owner or operator shall submit to the reviewing authority the results of any re-validation test or method within 3 months after completion of such test or method.

15. *Transition requirements.*

(i) No reviewing authority may issue a PAL that does not comply with the requirements in paragraphs IV.K.1 through 15 of this Ruling after the date that this Ruling becomes effective for the State in which the major stationary source is located.

(ii) The reviewing authority may supersede any PAL which was established prior to the date that this Ruling becomes effective for the State in which the major stationary source is located with a PAL that complies with the requirements of paragraphs IV.K.1 through 15 of this Ruling.

L. *Severability.* If any provision of this Ruling, or the application of such provision to any person or circumstance, is held invalid, the remainder of this Ruling, or the application of such provision to persons or circumstances other than those as to which it is held invalid, shall not be affected thereby.

V. ADMINISTRATIVE PROCEDURES

The necessary emission offsets may be proposed either by the owner of the proposed source or by the local community or the State. The emission reduction committed to must be enforceable by authorized State and/or local agencies and under the Clean Air Act, and must be accomplished by the new source's start-up date. If emission reductions are to be obtained in a State that neighbors the State in which the new source is to be located, the emission reductions committed to must be enforceable by the neighboring State and/or local agencies and under the Clean Air Act. Where the new facility is a replacement for a facility that is being shut down in order to provide the necessary offsets, the reviewing authority may allow up to 180 days for shakedown of the new facility before the existing facility is required to cease operation.

A. *Source initiated emission offsets.* A source may propose emission offsets which involve:

(1) Reductions from sources controlled by the source owner (internal emission offsets); and/or (2) reductions from neighboring sources (external emission offsets). The source does not have to investigate all possible emission offsets. As long as the emission offsets obtained represent reasonable progress toward attainment, they will be acceptable. It is the reviewing authority's responsibility to assure that the emission offsets will be as effective as proposed by the source. An internal emission offset will be considered enforceable if it is made a SIP requirement by inclusion as a condition of the new source permit and the permit is forwarded to the appropriate EPA Regional Office.⁷ An external emission offset will not be enforceable unless the affected source(s) providing the emission reductions is subject to a new SIP requirement to ensure that its emissions will be reduced by a specified amount in a specified time. Thus, if the source(s) providing the emission reductions does not obtain the necessary reduction, it will be in violation of a SIP requirement and subject to enforcement action by EPA, the State and/or private parties.

The form of the SIP revision may be a State or local regulation, operating permit condition, consent or enforcement order, or any other mechanism available to the State that is enforceable under the Clean Air Act. If a SIP revision is required, the public hearing on the revision may be substituted for the normal public comment procedure required for all major sources under 40 CFR 51.18. The formal publication of the SIP revision approval in the FEDERAL REGISTER need not appear before the source may proceed with construction. To minimize uncertainty that may be caused by these procedures, EPA will, if requested by the State, propose a SIP revision for public comment in the FEDERAL REGISTER concurrently with the State public hearing process. Of course, any major change in the final permit/SIP revision submitted by the State may require a reproposal by EPA.

B. *State or community initiated emission offsets.* A State or community which desires that a source locate in its area may commit to reducing emissions from existing sources (including mobile sources) to sufficiently outweigh the impact of the new source and thus open the way for the new source. As with source-initiated emission offsets, the commitment must be something more than

one-for-one. This commitment must be submitted as a SIP revision by the State.

VI. POLICY WHERE ATTAINMENT DATES HAVE NOT PASSED

In some cases, the dates for attainment of primary standards specified in the SIP under section 110 have not yet passed due to a delay in the promulgation of a plan under this section of the Act. In addition the Act provides more flexibility with respect to the dates for attainment of secondary NAAQS than for primary standards. Rather than setting specific deadlines, section 110 requires secondary NAAQS to be achieved within a "reasonable time". Therefore, in some cases, the date for attainment of secondary standards specified in the SIP under section 110 may also not yet have passed. In such cases, a new source locating in an area designated in 40 CFR 81.300 *et seq.* as nonattainment (or, where section III of this Ruling is applicable, a new source that would cause or contribute to a NAAQS violation) may be exempt from the Conditions of section IV.A if the conditions in paragraphs VI.A through C are met.

A. The new source meets the applicable SIP emission limitations.

B. The new source will not interfere with the attainment date specified in the SIP under section 110 of the Act.

C. The Administrator has determined that conditions A and B of this section are satisfied and such determination is published in the FEDERAL REGISTER.

(Secs. 101(b)(1), 110, 160-169, 171-178, and 301(a), Clean Air Act, as amended (42 U.S.C. 7401(b)(1), 7410, 7470-7479, 7501-7508, and 7601(a)); sec. 129(a), Clean Air Act Amendments of 1977 (Pub. L. 95-95, 91 Stat. 685 (Aug., 7, 1977)))

[44 FR 3282, Jan. 16, 1979, as amended at 45 FR 31311, May 13, 1980; 45 FR 52741, Aug. 7, 1980; 45 FR 59879, Sept. 11, 1980; 46 FR 50771, Oct. 14, 1981; 47 FR 27561, June 25, 1982; 49 FR 43210, Oct. 26, 1984; 51 FR 40661, 40675, Nov. 7, 1986; 52 FR 24714, July 1, 1987; 52 FR 29386, Aug. 7, 1987; 54 FR 27285, 27299, June 28, 1989; 57 FR 3946, Feb. 3, 1992; 70 FR 71702, Nov. 29, 2005; 72 FR 10373, Mar. 8, 2007]

EFFECTIVE DATE NOTE: At 72 FR 24077, May 1, 2007, Appendix S to part 51; was amended by revising paragraphs II.A.4.(iii)(t), and II.F.(20), effective July 2, 2007. For the convenience of the user, the revised text is set forth as follows:

APPENDIX S TO PART 51—EMISSION OFFSET INTERPRETATIVE RULING

* * * * *

II. * * *

A. * * *

4. * * *

⁷The emission offset will, therefore, be enforceable by EPA under section 113 as an applicable SIP requirement and will be enforceable by private parties under section 304 as an emission limitation.

(iii) * * *

(t) Chemical process plants—The term chemical processing plant shall not include ethanol production facilities that produce ethanol by natural fermentation included in NAICS codes 325193 or 312140;

* * * * *

F. * * *

(20) Chemical process plants—The term chemical processing plant shall not include ethanol production facilities that produce ethanol by natural fermentation included in NAICS codes 325193 or 312140;

* * * * *

APPENDIXES T–U TO PART 51 [RESERVED]

APPENDIX V TO PART 51—CRITERIA FOR DETERMINING THE COMPLETENESS OF PLAN SUBMISSIONS

1.0. PURPOSE

This appendix V sets forth the minimum criteria for determining whether a State implementation plan submitted for consideration by EPA is an official submission for purposes of review under §51.103.

1.1 The EPA shall return to the submitting official any plan or revision thereof which fails to meet the criteria set forth in this appendix V, and request corrective action, identifying the component(s) absent or insufficient to perform a review of the submitted plan.

1.2 The EPA shall inform the submitting official whether or not a plan submission meets the requirements of this appendix V within 60 days of EPA's receipt of the submittal, but no later than 6 months after the date by which the State was required to submit the plan or revision. If a completeness determination is not made by 6 months from receipt of a submittal, the submittal shall be deemed complete by operation of law on the date 6 months from receipt. A determination of completeness under this paragraph means that the submission is an official submission for purposes of §51.103.

2.0. CRITERIA

The following shall be included in plan submissions for review by EPA:

2.1. Administrative Materials

(a) A formal letter of submittal from the Governor or his designee, requesting EPA approval of the plan or revision thereof (hereafter “the plan”).

(b) Evidence that the State has adopted the plan in the State code or body of regulations; or issued the permit, order, consent agreement (hereafter “document”) in final

form. That evidence shall include the date of adoption or final issuance as well as the effective date of the plan, if different from the adoption/issuance date.

(c) Evidence that the State has the necessary legal authority under State law to adopt and implement the plan.

(d) A copy of the actual regulation, or document submitted for approval and incorporation by reference into the plan, including indication of the changes made to the existing approved plan, where applicable. The submittal shall be a copy of the official State regulation /document signed, stamped, dated by the appropriate State official indicating that it is fully enforceable by the State. The effective date of the regulation/document shall, whenever possible, be indicated in the document itself.

(e) Evidence that the State followed all of the procedural requirements of the State's laws and constitution in conducting and completing the adoption/issuance of the plan.

(f) Evidence that public notice was given of the proposed change consistent with procedures approved by EPA, including the date of publication of such notice.

(g) Certification that public hearings(s) were held in accordance with the information provided in the public notice and the State's laws and constitution, if applicable.

(h) Compilation of public comments and the State's response thereto.

2.2. Technical Support

(a) Identification of all regulated pollutants affected by the plan.

(b) Identification of the locations of affected sources including the EPA attainment/nonattainment designation of the locations and the status of the attainment plan for the affected areas(s).

(c) Quantification of the changes in plan allowable emissions from the affected sources; estimates of changes in current actual emissions from affected sources or, where appropriate, quantification of changes in actual emissions from affected sources through calculations of the differences between certain baseline levels and allowable emissions anticipated as a result of the revision.

(d) The State's demonstration that the national ambient air quality standards, prevention of significant deterioration increments, reasonable further progress demonstration, and visibility, as applicable, are protected if the plan is approved and implemented. For all requests to redesignate an area to attainment for a national primary ambient air quality standard, under section 107 of the Act, a revision must be submitted to provide for the maintenance of the national primary ambient air quality standards for at least 10 years as required by section 175A of the Act.

(e) Modeling information required to support the proposed revision, including input

data, output data, models used, justification of model selections, ambient monitoring data used, meteorological data used, justification for use of offsite data (where used), modes of models used, assumptions, and other information relevant to the determination of adequacy of the modeling analysis.

(f) Evidence, where necessary, that emission limitations are based on continuous emission reduction technology.

(g) Evidence that the plan contains emission limitations, work practice standards and recordkeeping/reporting requirements, where necessary, to ensure emission levels.

(h) Compliance/enforcement strategies, including how compliance will be determined in practice.

(i) Special economic and technological justifications required by any applicable EPA policies, or an explanation of why such justifications are not necessary.

2.3. Exceptions

2.3.1. The EPA, for the purposes of expediting the review of the plan, has adopted a procedure referred to as "parallel processing." Parallel processing allows a State to submit the plan prior to actual adoption by the State and provides an opportunity for the State to consider EPA comments prior to submission of a final plan for final review and action. Under these circumstances, the plan submitted will not be able to meet all of the requirements of paragraph 2.1 (all requirements of paragraph 2.2 will apply). As a result, the following exceptions apply to plans submitted explicitly for parallel processing:

(a) The letter required by paragraph 2.1(a) shall request that EPA propose approval of the proposed plan by parallel processing.

(b) In lieu of paragraph 2.1(b) the State shall submit a schedule for final adoption or issuance of the plan.

(c) In lieu of paragraph 2.1(d) the plan shall include a copy of the proposed/draft regulation or document, including indication of the proposed changes to be made to the existing approved plan, where applicable.

(d) The requirements of paragraphs 2.1(e)–2.1(h) shall not apply to plans submitted for parallel processing.

2.3.2. The exceptions granted in paragraph 2.3.1 shall apply only to EPA's determination of proposed action and all requirements of paragraph 2.1 shall be met prior to publication of EPA's final determination of plan approvability.

[55 FR 5830, Feb. 16, 1990, as amended at 56 FR 42219, Aug. 26, 1991; 56 FR 57288, Nov. 8, 1991]

APPENDIX W TO PART 51—GUIDELINE ON AIR QUALITY MODELS

PREFACE

a. Industry and control agencies have long expressed a need for consistency in the application of air quality models for regulatory purposes. In the 1977 Clean Air Act, Congress mandated such consistency and encouraged the standardization of model applications. The *Guideline on Air Quality Models* (hereafter, *Guideline*) was first published in April 1978 to satisfy these requirements by specifying models and providing guidance for their use. The *Guideline* provides a common basis for estimating the air quality concentrations of criteria pollutants used in assessing control strategies and developing emission limits.

b. The continuing development of new air quality models in response to regulatory requirements and the expanded requirements for models to cover even more complex problems have emphasized the need for periodic review and update of guidance on these techniques. Historically, three primary activities have provided direct input to revisions of the *Guideline*. The first is a series of annual EPA workshops conducted for the purpose of ensuring consistency and providing clarification in the application of models. The second activity was the solicitation and review of new models from the technical and user community. In the March 27, 1980 FEDERAL REGISTER, a procedure was outlined for the submittal to EPA of privately developed models. After extensive evaluation and scientific review, these models, as well as those made available by EPA, have been considered for recognition in the *Guideline*. The third activity is the extensive on-going research efforts by EPA and others in air quality and meteorological modeling.

c. Based primarily on these three activities, new sections and topics have been included as needed. EPA does not make changes to the guidance on a predetermined schedule, but rather on an as-needed basis. EPA believes that revisions of the *Guideline* should be timely and responsive to user needs and should involve public participation to the greatest possible extent. All future changes to the guidance will be proposed and finalized in the FEDERAL REGISTER. Information on the current status of modeling guidance can always be obtained from EPA's Regional Offices.

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1.0 INTRODUCTION

a. The *Guideline* recommends air quality modeling techniques that should be applied to State Implementation Plan (SIP) revisions for existing sources and to new source reviews (NSR), including prevention of significant deterioration (PSD).^{1,2,3} Applicable only to criteria air pollutants, it is intended for use by EPA Regional Offices in judging the adequacy of modeling analyses performed by EPA, State and local agencies and by industry. The guidance is appropriate for use by other Federal agencies and by State agencies with air quality and land management responsibilities. The *Guideline* serves to identify, for all interested parties, those techniques and data bases EPA considers acceptable. The *Guideline* is not intended to be a compendium of modeling techniques. Rather, it should serve as a common measure of acceptable technical analysis when supported by sound scientific judgment.

b. Due to limitations in the spatial and temporal coverage of air quality measurements, monitoring data normally are not sufficient as the sole basis for demonstrating the adequacy of emission limits for existing sources. Also, the impacts of new sources that do not yet exist can only be determined through modeling. Thus, models, while

uniquely filling one program need, have become a primary analytical tool in most air quality assessments. Air quality measurements can be used in a complementary manner to dispersion models, with due regard for the strengths and weaknesses of both analysis techniques. Measurements are particularly useful in assessing the accuracy of model estimates. The use of air quality measurements alone however could be preferable, as detailed in a later section of this document, when models are found to be unacceptable and monitoring data with sufficient spatial and temporal coverage are available.

c. It would be advantageous to categorize the various regulatory programs and to apply a designated model to each proposed source needing analysis under a given program. However, the diversity of the nation's topography and climate, and variations in source configurations and operating characteristics dictate against a strict modeling "cookbook". There is no one model capable of properly addressing all conceivable situations even within a broad category such as point sources. Meteorological phenomena associated with threats to air quality standards are rarely amenable to a single mathematical treatment; thus, case-by-case analysis and judgment are frequently required. As modeling efforts become more complex, it is increasingly important that they be directed by highly competent individuals with a broad range of experience and knowledge in air quality meteorology. Further, they should be coordinated closely with specialists in emissions characteristics, air monitoring and data processing. The judgment of experienced meteorologists and analysts is essential.

d. The model that most accurately estimates concentrations in the area of interest is always sought. However, it is clear from the needs expressed by the States and EPA Regional Offices, by many industries and trade associations, and also by the deliberations of Congress, that consistency in the selection and application of models and data bases should also be sought, even in case-by-case analyses. Consistency ensures that air quality control agencies and the general public have a common basis for estimating pollutant concentrations, assessing control strategies and specifying emission limits. Such consistency is not, however, promoted at the expense of model and data base accuracy. The *Guideline* provides a consistent basis for selection of the most accurate models and data bases for use in air quality assessments.

e. Recommendations are made in the *Guideline* concerning air quality models, data bases, requirements for concentration estimates, the use of measured data in lieu of model estimates, and model evaluation procedures. Models are identified for some spe-

cific applications. The guidance provided here should be followed in air quality analyses relative to State Implementation Plans and in supporting analyses required by EPA, State and local agency air programs. EPA may approve the use of another technique that can be demonstrated to be more appropriate than those recommended in this guide. This is discussed at greater length in Section 3. In all cases, the model applied to a given situation should be the one that provides the most accurate representation of atmospheric transport, dispersion, and chemical transformations in the area of interest. However, to ensure consistency, deviations from this guide should be carefully documented and fully supported.

f. From time to time situations arise requiring clarification of the intent of the guidance on a specific topic. Periodic workshops are held with the headquarters, Regional Office, State, and local agency modeling representatives to ensure consistency in modeling guidance and to promote the use of more accurate air quality models and data bases. The workshops serve to provide further explanations of *Guideline* requirements to the Regional Offices and workshop reports are issued with this clarifying information. In addition, findings from ongoing research programs, new model development, or results from model evaluations and applications are continuously evaluated. Based on this information changes in the guidance may be indicated.

g. All changes to the *Guideline* must follow rulemaking requirements since the *Guideline* is codified in Appendix W of Part 51. EPA will promulgate proposed and final rules in the FEDERAL REGISTER to amend this Appendix. Ample opportunity for public comment will be provided for each proposed change and public hearings scheduled if requested.

h. A wide range of topics on modeling and data bases are discussed in the *Guideline*. Section 2 gives an overview of models and their appropriate use. Section 3 provides specific guidance on the use of "preferred" air quality models and on the selection of alternative techniques. Sections 4 through 7 provide recommendations on modeling techniques for application to simple-terrain stationary source problems, complex terrain problems, and mobile source problems. Specific modeling requirements for selected regulatory issues are also addressed. Section 8 discusses issues common to many modeling analyses, including acceptable model components. Section 9 makes recommendations for data inputs to models including source, meteorological and background air quality data. Section 10 covers the uncertainty in model estimates and how that information can be useful to the regulatory decision-maker. The last chapter summarizes how estimates and measurements of air quality are

used in assessing source impact and in evaluating control strategies.

i. Appendix W to 40 CFR Part 51 itself contains an appendix: Appendix A. Thus, when reference is made to “Appendix A” in this document, it refers to Appendix A to Appendix W to 40 CFR Part 51. Appendix A contains summaries of refined air quality models that are “preferred” for specific applications; both EPA models and models developed by others are included.

2.0 OVERVIEW OF MODEL USE

a. Before attempting to implement the guidance contained in this document, the reader should be aware of certain general information concerning air quality models and their use. Such information is provided in this section.

2.1 Suitability of Models

a. The extent to which a specific air quality model is suitable for the evaluation of source impact depends upon several factors. These include: (1) The meteorological and topographic complexities of the area; (2) the level of detail and accuracy needed for the analysis; (3) the technical competence of those undertaking such simulation modeling; (4) the resources available; and (5) the detail and accuracy of the data base, *i.e.*, emissions inventory, meteorological data, and air quality data. Appropriate data should be available before any attempt is made to apply a model. A model that requires detailed, precise, input data should not be used when such data are unavailable. However, assuming the data are adequate, the greater the detail with which a model considers the spatial and temporal variations in emissions and meteorological conditions, the greater the ability to evaluate the source impact and to distinguish the effects of various control strategies.

b. Air quality models have been applied with the most accuracy, or the least degree of uncertainty, to simulations of long term averages in areas with relatively simple topography. Areas subject to major topographic influences experience meteorological complexities that are extremely difficult to simulate. Although models are available for such circumstances, they are frequently site specific and resource intensive. In the absence of a model capable of simulating such complexities, only a preliminary approximation may be feasible until such time as better models and data bases become available.

c. Models are highly specialized tools. Competent and experienced personnel are an essential prerequisite to the successful application of simulation models. The need for specialists is critical when the more sophisticated models are used or the area being investigated has complicated meteorological or topographic features. A model applied im-

properly, or with inappropriate data, can lead to serious misjudgements regarding the source impact or the effectiveness of a control strategy.

d. The resource demands generated by use of air quality models vary widely depending on the specific application. The resources required depend on the nature of the model and its complexity, the detail of the data base, the difficulty of the application, and the amount and level of expertise required. The costs of manpower and computational facilities may also be important factors in the selection and use of a model for a specific analysis. However, it should be recognized that under some sets of physical circumstances and accuracy requirements, no present model may be appropriate. Thus, consideration of these factors should lead to selection of an appropriate model.

2.2 Levels of Sophistication of Models

a. There are two levels of sophistication of models. The first level consists of relatively simple estimation techniques that generally use preset, worst-case meteorological conditions to provide conservative estimates of the air quality impact of a specific source, or source category. These are called screening techniques or screening models. The purpose of such techniques is to eliminate the need of more detailed modeling for those sources that clearly will not cause or contribute to ambient concentrations in excess of either the National Ambient Air Quality Standards (NAAQS)⁴ or the allowable prevention of significant deterioration (PSD) concentration increments.^{2,3} If a screening technique indicates that the concentration contributed by the source exceeds the PSD increment or the increment remaining to just meet the NAAQS, then the second level of more sophisticated models should be applied.

b. The second level consists of those analytical techniques that provide more detailed treatment of physical and chemical atmospheric processes, require more detailed and precise input data, and provide more specialized concentration estimates. As a result they provide a more refined and, at least theoretically, a more accurate estimate of source impact and the effectiveness of control strategies. These are referred to as refined models.

c. The use of screening techniques followed, as appropriate, by a more refined analysis is always desirable. However there are situations where the screening techniques are practically and technically the only viable option for estimating source impact. In such cases, an attempt should be made to acquire or improve the necessary data bases and to develop appropriate analytical techniques.

2.3 Availability of Models

a. For most of the screening and refined models discussed in the *Guideline*, codes, associated documentation and other useful information are available for download from EPA's Support Center for Regulatory Air Modeling (SCRAM) Internet Web site at <http://www.epa.gov/scram001>. A list of alternate models that can be used with case-by-case justification (subsection 3.2) and an example air quality analysis checklist are also posted on this Web site. This is a site with which modelers should become familiar.

3.0 RECOMMENDED AIR QUALITY MODELS

a. This section recommends the approach to be taken in determining refined modeling techniques for use in regulatory air quality programs. The status of models developed by EPA, as well as those submitted to EPA for review and possible inclusion in this guidance, is discussed. The section also addresses the selection of models for individual cases and provides recommendations for situations where the preferred models are not applicable. Two additional sources of modeling guidance are the Model Clearinghouse⁵ and periodic Regional/State/Local Modelers workshops.

b. In this guidance, when approval is required for a particular modeling technique or analytical procedure, we often refer to the "appropriate reviewing authority". In some EPA regions, authority for NSR and PSD permitting and related activities has been delegated to State and even local agencies. In these cases, such agencies are "representatives" of the respective regions. Even in these circumstances, the Regional Office retains the ultimate authority in decisions and approvals. Therefore, as discussed above and depending on the circumstances, the appropriate reviewing authority may be the Regional Office, Federal Land Manager(s), State agency(ies), or perhaps local agency(ies). In cases where review and approval comes solely from the Regional Office (sometimes stated as "Regional Administrator"), this will be stipulated. If there is any question as to the appropriate reviewing authority, you should contact the Regional modeling contact (<http://www.epa.gov/scram001/tt28.htm#regionalmodelingcontacts>) in the appropriate EPA Regional Office, whose jurisdiction generally includes the physical location of the source in question and its expected impacts.

c. In all regulatory analyses, especially if other-than-preferred models are selected for use, early discussions among Regional Office staff, State and local control agencies, industry representatives, and where appropriate, the Federal Land Manager, are invaluable and are encouraged. Agreement on the data base(s) to be used, modeling techniques to be applied and the overall tech-

nical approach, prior to the actual analyses, helps avoid misunderstandings concerning the final results and may reduce the later need for additional analyses. The use of an air quality analysis checklist, such as is posted on EPA's Internet SCRAM Web site (subsection 2.3), and the preparation of a written protocol help to keep misunderstandings at a minimum.

d. It should not be construed that the preferred models identified here are to be permanently used to the exclusion of all others or that they are the only models available for relating emissions to air quality. The model that most accurately estimates concentrations in the area of interest is always sought. However, designation of specific models is needed to promote consistency in model selection and application.

e. The 1980 solicitation of new or different models from the technical community⁶ and the program whereby these models were evaluated, established a means by which new models are identified, reviewed and made available in the *Guideline*. There is a pressing need for the development of models for a wide range of regulatory applications. Refined models that more realistically simulate the physical and chemical process in the atmosphere and that more reliably estimate pollutant concentrations are needed.

3.1 Preferred Modeling Techniques

3.1.1 Discussion

a. EPA has developed models suitable for regulatory application. Other models have been submitted by private developers for possible inclusion in the *Guideline*. Refined models which are preferred and recommended by EPA have undergone evaluation exercises^{7,8,9,10} that include statistical measures of model performance in comparison with measured air quality data as suggested by the American Meteorological Society¹¹ and, where possible, peer scientific reviews.^{12,13,14}

b. When a single model is found to perform better than others, it is recommended for application as a preferred model and listed in Appendix A. If no one model is found to clearly perform better through the evaluation exercise, then the preferred model listed in Appendix A may be selected on the basis of other factors such as past use, public familiarity, cost or resource requirements, and availability. Accordingly, dispersion models listed in Appendix A meet these conditions:

i. The model must be written in a common programming language, and the executable(s) must run on a common computer platform.

ii. The model must be documented in a user's guide which identifies the mathematics of the model, data requirements and program operating characteristics at a level

of detail comparable to that available for other recommended models in Appendix A.

iii. The model must be accompanied by a complete test data set including input parameters and output results. The test data must be packaged with the model in computer-readable form.

iv. The model must be useful to typical users, e.g., State air pollution control agencies, for specific air quality control problems. Such users should be able to operate the computer program(s) from available documentation.

v. The model documentation must include a comparison with air quality data (and/or tracer measurements) or with other well-established analytical techniques.

vi. The developer must be willing to make the model and source code available to users at reasonable cost or make them available for public access through the Internet or National Technical Information Service; The model and its code cannot be proprietary.

c. The evaluation process includes a determination of technical merit, in accordance with the above six items including the practicality of the model for use in ongoing regulatory programs. Each model will also be subjected to a performance evaluation for an appropriate data base and to a peer scientific review. Models for wide use (not just an isolated case) that are found to perform better will be proposed for inclusion as preferred models in future *Guideline* revisions.

d. No further evaluation of a preferred model is required for a particular application if the EPA recommendations for regulatory use specified for the model in the *Guideline* are followed. Alternative models to those listed in Appendix A should generally be compared with measured air quality data when they are used for regulatory applications consistent with recommendations in subsection 3.2.

3.1.2 Recommendations

a. Appendix A identifies refined models that are preferred for use in regulatory applications. If a model is required for a particular application, the user should select a model from that appendix. These models may be used without a formal demonstration of applicability as long as they are used as indicated in each model summary of Appendix A. Further recommendations for the application of these models to specific source problems are found in subsequent sections of the *Guideline*.

b. If changes are made to a preferred model without affecting the concentration estimates, the preferred status of the model is unchanged. Examples of modifications that do not affect concentrations are those made to enable use of a different computer platform or those that affect only the format or averaging time of the model results. However, when any changes are made, the Re-

gional Administrator should require a test case example to demonstrate that the concentration estimates are not affected.

c. A preferred model should be operated with the options listed in Appendix A as “Recommendations for Regulatory Use.” If other options are exercised, the model is no longer “preferred.” Any other modification to a preferred model that would result in a change in the concentration estimates likewise alters its status as a preferred model. Use of the model must then be justified on a case-by-case basis.

3.2 Use of Alternative Models

3.2.1 Discussion

a. Selection of the best techniques for each individual air quality analysis is always encouraged, but the selection should be done in a consistent manner. A simple listing of models in this *Guideline* cannot alone achieve that consistency nor can it necessarily provide the best model for all possible situations. An EPA reference¹⁵ provides a statistical technique for evaluating model performance for predicting peak concentration values, as might be observed at individual monitoring locations. This protocol is available to assist in developing a consistent approach when justifying the use of other-than-preferred modeling techniques recommended in the *Guideline*. The procedures in this protocol provide a general framework for objective decision-making on the acceptability of an alternative model for a given regulatory application. These objective procedures may be used for conducting both the technical evaluation of the model and the field test or performance evaluation. An ASTM reference¹⁶ provides a general philosophy for developing and implementing advanced statistical evaluations of atmospheric dispersion models, and provides an example statistical technique to illustrate the application of this philosophy.

b. This section discusses the use of alternate modeling techniques and defines three situations when alternative models may be used.

3.2.2 Recommendations

a. Determination of acceptability of a model is a Regional Office responsibility. Where the Regional Administrator finds that an alternative model is more appropriate than a preferred model, that model may be used subject to the recommendations of this subsection. This finding will normally result from a determination that (1) a preferred air quality model is not appropriate for the particular application; or (2) a more appropriate model or analytical procedure is available and applicable.

b. An alternative model should be evaluated from both a theoretical and a performance perspective before it is selected for use.

There are three separate conditions under which such a model may normally be approved for use: (1) If a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model; (2) if a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the given application than a comparable model in Appendix A; or (3) if the preferred model is less appropriate for the specific application, or there is no preferred model. Any one of these three separate conditions may make use of an alternative model acceptable. Some known alternative models that are applicable for selected situations are listed on EPA's SCRAM Internet Web site (subsection 2.3). However, inclusion there does not confer any unique status relative to other alternative models that are being or will be developed in the future.

c. Equivalency, condition (1) in paragraph (b) of this subsection, is established by demonstrating that the maximum or highest, second highest concentrations are within 2 percent of the estimates obtained from the preferred model. The option to show equivalency is intended as a simple demonstration of acceptability for an alternative model that is so nearly identical (or contains options that can make it identical) to a preferred model that it can be treated for practical purposes as the preferred model. Two percent was selected as the basis for equivalency since it is a rough approximation of the fraction that PSD Class I increments are of the NAAQS for SO₂, i.e., the difference in concentrations that is judged to be significant. However, notwithstanding this demonstration, models that are not equivalent may be used when one of the two other conditions described in paragraphs (d) and (e) of this subsection are satisfied.

d. For condition (2) in paragraph (b) of this subsection, established procedures and techniques^{15,16} for determining the acceptability of a model for an individual case based on superior performance should be followed, as appropriate. Preparation and implementation of an evaluation protocol which is acceptable to both control agencies and regulated industry is an important element in such an evaluation.

e. Finally, for condition (3) in paragraph (b) of this subsection, an alternative refined model may be used provided that:

- i. The model has received a scientific peer review;
- ii. The model can be demonstrated to be applicable to the problem on a theoretical basis;
- iii. The data bases which are necessary to perform the analysis are available and adequate;

iv. Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates; and

v. A protocol on methods and procedures to be followed has been established.

3.3 Availability of Supplementary Modeling Guidance

a. The Regional Administrator has the authority to select models that are appropriate for use in a given situation. However, there is a need for assistance and guidance in the selection process so that fairness and consistency in modeling decisions is fostered among the various Regional Offices and the States. To satisfy that need, EPA established the Model Clearinghouse⁵ and also holds periodic workshops with headquarters, Regional Office, State, and local agency modeling representatives.

b. The Regional Office should always be consulted for information and guidance concerning modeling methods and interpretations of modeling guidance, and to ensure that the air quality model user has available the latest most up-to-date policy and procedures. As appropriate, the Regional Office may request assistance from the Model Clearinghouse after an initial evaluation and decision has been reached concerning the application of a model, analytical technique or data base in a particular regulatory action.

4.0 TRADITIONAL STATIONARY SOURCE MODELS

4.1 Discussion

a. Guidance in this section applies to modeling analyses for which the predominant meteorological conditions that control the design concentration are steady state and for which the transport distances are nominally 50km or less. The models recommended in this section are generally used in the air quality impact analysis of stationary sources for most criteria pollutants. The averaging time of the concentration estimates produced by these models ranges from 1 hour to an annual average.

b. Simple terrain, as used here, is considered to be an area where terrain features are all lower in elevation than the top of the stack of the source(s) in question. Complex terrain is defined as terrain exceeding the height of the stack being modeled.

c. In the early 1980s, model evaluation exercises were conducted to determine the "best, most appropriate point source model" for use in simple terrain.¹² No one model was found to be clearly superior and, based on past use, public familiarity, and availability, ISC (predecessor to ISC3¹⁷) became the recommended model for a wide range of regulatory applications. Other refined models which also employed the same basic Gaussian kernel as in ISC, i.e., BLP,

CALINE3 and OCD, were developed for specialized applications (Appendix A). Performance evaluations were also made for these models, which are identified below.

d. Encouraged by the development of pragmatic methods for better characterization of plume dispersion^{18,19,20,21} the AMS/EPA Regulatory Model Improvement Committee (AERMIC) developed AERMOD.²² AERMOD employs best state-of-practice parameterizations for characterizing the meteorological influences and dispersion. The model utilizes a probability density function (pdf) and the superposition of several Gaussian plumes to characterize the distinctly non-Gaussian nature of the vertical pollutant distribution for elevated plumes during convective conditions; otherwise the distribution is Gaussian. Also, nighttime urban boundary layers (and plumes within them) have the turbulence enhanced by AERMOD to simulate the influence of the urban heat island. AERMOD has been evaluated using a variety of data sets and has been found to perform better than ISC3 for many applications, and as well or better than CTDMPPLUS for several complex terrain data sets (Section A.1; subsection n). The current version of AERMOD has been modified to include an algorithm for dry and wet deposition for both gases and particles. Note that when deposition is invoked, mass in the plume is depleted. Availability of this version is described in Section A.1, and is subject to applicable guidance published in the *Guideline*.

e. A new building downwash algorithm²³ was developed and tested within AERMOD. The PRIME algorithm has been evaluated using a variety of data sets and has been found to perform better than the downwash algorithm that is in ISC3, and has been shown to perform acceptably in tests within AERMOD (Section A.1; subsection n).

4.2 Recommendations

4.2.1 Screening Techniques

4.2.1.1 Simple Terrain

a. Where a preliminary or conservative estimate is desired, point source screening techniques are an acceptable approach to air quality analyses. EPA has published guidance for screening procedures.^{24,25}

b. All screening procedures should be adjusted to the site and problem at hand. Close attention should be paid to whether the area should be classified urban or rural in accordance with Section 7.2.3. The climatology of the area should be studied to help define the worst-case meteorological conditions. Agreement should be reached between the model user and the appropriate reviewing authority on the choice of the screening model for each analysis, and on the input data as well as the ultimate use of the results.

4.2.1.2 Complex Terrain

a. CTSCREEN²⁶ can be used to obtain conservative, yet realistic, worst-case estimates for receptors located on terrain above stack height. CTSCREEN accounts for the three-dimensional nature of plume and terrain interaction and requires detailed terrain data representative of the modeling domain. The model description and user's instructions are contained in the user's guide.²⁶ The terrain data must be digitized in the same manner as for CTDMPPLUS and a terrain processor is available.²⁷ A discussion of the model's performance characteristics is provided in a technical paper.²⁸ CTSCREEN is designed to execute a fixed matrix of meteorological values for wind speed (u), standard deviation of horizontal and vertical wind speeds (σ_v , σ_w), vertical potential temperature gradient ($d\theta/dz$), friction velocity (u_*), Monin-Obukhov length (L), mixing height (z_i) as a function of terrain height, and wind directions for both neutral/stable conditions and unstable convective conditions. Table 4-1 contains the matrix of meteorological variables that is used for each CTSCREEN analysis. There are 96 combinations, including exceptions, for each wind direction for the neutral/stable case, and 108 combinations for the unstable case. The specification of wind direction, however, is handled internally, based on the source and terrain geometry. Although CTSCREEN is designed to address a single source scenario, there are a number of options that can be selected on a case-by-case basis to address multi-source situations. However, the appropriate reviewing authority should be consulted, and concurrence obtained, on the protocol for modeling multiple sources with CTSCREEN to ensure that the worst case is identified and assessed. The maximum concentration output from CTSCREEN represents a worst-case 1-hour concentration. Time-scaling factors of 0.7 for 3-hour, 0.15 for 24-hour and 0.03 for annual concentration averages are applied internally by CTSCREEN to the highest 1-hour concentration calculated by the model.

b. Placement of receptors requires very careful attention when modeling in complex terrain. Often the highest concentrations are predicted to occur under very stable conditions, when the plume is near, or impinges on, the terrain. The plume under such conditions may be quite narrow in the vertical, so that even relatively small changes in a receptor's location may substantially affect the predicted concentration. Receptors within about a kilometer of the source may be even more sensitive to location. Thus, a dense array of receptors may be required in some cases. In order to avoid excessively large computer runs due to such a large array of receptors, it is often desirable to model the area twice. The first model run would use a moderate number of receptors

carefully located over the area of interest. The second model run would use a more dense array of receptors in areas showing potential for high concentrations, as indicated by the results of the first model run.

c. As mentioned above, digitized contour data must be preprocessed²⁷ to provide hill shape parameters in suitable input format. The user then supplies receptors either through an interactive program that is part of the model or directly, by using a text editor; using both methods to select receptors will generally be necessary to assure that the maximum concentrations are estimated by either model. In cases where a terrain feature may “appear to the plume” as smaller, multiple hills, it may be necessary to model the terrain both as a single feature and as multiple hills to determine design concentrations.

d. Other screening techniques^{17,25,29} may be acceptable for complex terrain cases where established procedures are used. The user is encouraged to confer with the appropriate reviewing authority if any unresolvable problems are encountered, *e.g.*, applicability, meteorological data, receptor siting, or terrain contour processing issues.

4.2.2 Refined Analytical Techniques

a. A brief description of each preferred model for refined applications is found in Appendix A. Also listed in that appendix are availability, the model input requirements, the standard options that should be selected when running the program, and output options.

b. For a wide range of regulatory applications in all types of terrain, the rec-

ommended model is AERMOD. This recommendation is based on extensive developmental and performance evaluation (Section A.1; subsection n). Differentiation of simple versus complex terrain is unnecessary with AERMOD. In complex terrain, AERMOD employs the well-known dividing-streamline concept in a simplified simulation of the effects of plume-terrain interactions.

c. If aerodynamic building downwash is important for the modeling analysis, *e.g.*, paragraph 6.2.2(b), then the recommended model is AERMOD. The state-of-the-science for modeling atmospheric deposition is evolving and the best techniques are currently being assessed and their results are being compared with observations. Consequently, while deposition treatment is available in AERMOD, the approach taken for any purpose should be coordinated with the appropriate reviewing authority. Line sources can be simulated with AERMOD if point or volume sources are appropriately combined. If buoyant plume rise from line sources is important for the modeling analysis, the recommended model is BLP. For other special modeling applications, CALINE3 (or CAL3QHCR on a case-by-case basis), OCD, and EDMS are available as described in Sections 5 and 6.

d. If the modeling application involves a well defined hill or ridge and a detailed dispersion analysis of the spatial pattern of plume impacts is of interest, CDTMPLUS, listed in Appendix A, is available. CDTMPLUS provides greater resolution of concentrations about the contour of the hill feature than does AERMOD through a different plume-terrain interaction algorithm.

TABLE 4-1A—NEUTRAL/STABLE METEOROLOGICAL MATRIX FOR CTSCREEN

| Variable | Specific values | | | | |
|-------------------------------------|---|------|-------|------|-----|
| U (m/s) | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| σ_v (m/s) | 0.3 | 0.75 | | | |
| σ_w (m/s) | 0.08 | 0.15 | 0.30 | 0.75 | |
| $\Delta\theta/\Delta z$ (K/m) | 0.01 | 0.02 | 0.035 | | |
| WD | (Wind direction is optimized internally for each meteorological combination.) | | | | |

Exceptions:

(1) If $U \leq 2$ m/s and $\sigma_v \leq 0.3$ m/s, then include $\sigma_w = 0.04$ m/s.

(2) If $\sigma_w = 0.75$ m/s and $U \geq 3.0$ m/s, then $\Delta\theta/\Delta z$ is limited to ≤ 0.01 K/m.

(3) If $U \geq 4$ m/s, then $\sigma_w \geq 0.15$ m/s.

(4) $\sigma_w \leq \sigma_v$

TABLE 4-1B—UNSTABLE/CONVECTIVE METEOROLOGICAL MATRIX FOR CTSCREEN

| Variable | Specific values | | | | |
|-------------------|-----------------|-----|-----|-----|-----|
| U (m/s) | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| U_* (m/s) | 0.1 | 0.3 | 0.5 | | |
| L (m) | -10 | -50 | -90 | | |

TABLE 4–1B—UNSTABLE/CONVECTIVE METEOROLOGICAL MATRIX FOR CTSCREEN—Continued

| | | | | |
|-------------------------------------|-------|---|------|----------------------|
| $\Delta\theta/\Delta z$ (K/m) | 0.030 | (potential temperature gradient above Z_i) | | |
| Z_i (m) | 0.5h | 1.0h | 1.5h | (h = terrain height) |

5.0 MODELS FOR OZONE, PARTICULATE MATTER, CARBON MONOXIDE, NITROGEN DIOXIDE, AND LEAD

5.1 Discussion

a. This section identifies modeling approaches or models appropriate for addressing ozone (O_3)^a, carbon monoxide (CO), nitrogen dioxide (NO_2), particulates (PM-2.5^a and PM-10), and lead. These pollutants are often associated with emissions from numerous sources. Generally, mobile sources contribute significantly to emissions of these pollutants or their precursors. For cases where it is of interest to estimate concentrations of CO or NO_2 near a single or small group of stationary sources, refer to Section 4. (Modeling approaches for SO_2 are discussed in Section 4.)

b. Several of the pollutants mentioned in the preceding paragraph are closely related to each other in that they share common sources of emissions and/or are subject to chemical transformations of similar precursors.^{30,31} For example, strategies designed to reduce ozone could have an effect on the secondary component of PM-2.5 and vice versa. Thus, it makes sense to use models which take into account the chemical coupling between O_3 and PM-2.5, when feasible. This should promote consistency among methods used to evaluate strategies for reducing different pollutants as well as consistency among the strategies themselves. Regulatory requirements for the different pollutants are likely to be due at different times. Thus, the following paragraphs identify appropriate modeling approaches for pollutants individually.

c. The NAAQS for ozone was revised on July 18, 1997 and is now based on an 8-hour averaging period. Models for ozone are needed primarily to guide choice of strategies to correct an observed ozone problem in an area not attaining the NAAQS for ozone. Use of photochemical grid models is the recommended means for identifying strategies needed to correct high ozone concentrations in such areas. Such models need to consider emissions of volatile organic compounds (VOC), nitrogen oxides (NO_x) and carbon

monoxide (CO), as well as means for generating meteorological data governing transport and dispersion of ozone and its precursors. Other approaches, such as Lagrangian or observational models may be used to guide choice of appropriate strategies to consider with a photochemical grid model. These other approaches may be sufficient to address ozone in an area where observed concentrations are near the NAAQS or only slightly above it. Such a decision needs to be made on a case-by-case basis in concert with the Regional Office.

d. A control agency with jurisdiction over one or more areas with significant ozone problems should review available ambient air quality data to assess whether the problem is likely to be significantly impacted by regional transport.³² Choice of a modeling approach depends on the outcome of this review. In cases where transport is considered significant, use of a nested regional model may be the preferred approach. If the observed problem is believed to be primarily of local origin, use of a model with a single horizontal grid resolution and geographical coverage that is less than that of a regional model may suffice.

e. The fine particulate matter NAAQS, promulgated on July 18, 1997, includes particles with an aerodynamic diameter nominally less than or equal to 2.5 micrometers (PM-2.5). Models for PM-2.5 are needed to assess adequacy of a proposed strategy for meeting annual and/or 24-hour NAAQS for PM-2.5. PM-2.5 is a mixture consisting of several diverse components. Because chemical/physical properties and origins of each component differ, it may be appropriate to use either a single model capable of addressing several of the important components or to model primary and secondary components using different models. Effects of a control strategy on PM-2.5 is estimated from the sum of the effects on the components composing PM-2.5. Model users may refer to guidance³³ for further details concerning appropriate modeling approaches.

f. A control agency with jurisdiction over one or more areas with PM-2.5 problems should review available ambient air quality data to assess which components of PM-2.5 are likely to be major contributors to the problem. If it is determined that regional transport of secondary particulates, such as sulfates or nitrates, is likely to contribute significantly to the problem, use of a regional model may be the preferred approach. Otherwise, coverage may be limited to a domain that is urban scale or less. Special care

^a Modeling for attainment demonstrations for O_3 and PM-2.5 should be conducted in time to meet required SIP submission dates as provided for in the respective implementation rules. Information on implementation of the 8-hr O_3 and PM-2.5 standards is available at: <http://www.epa.gov/ttn/naaqs/>.

should be taken to select appropriate geographical coverage for a modeling application.³³

g. The NAAQS for PM-10 was promulgated in July 1987 (40 CFR 50.6). A SIP development guide³⁴ is available to assist in PM-10 analyses and control strategy development. EPA promulgated regulations for PSD increments measured as PM-10 in a notice published on June 3, 1993 (40 CFR 51.166(c)). As an aid to assessing the impact on ambient air quality of particulate matter generated from prescribed burning activities, a reference³⁵ is available.

h. Models for assessing the impacts of particulate matter may involve dispersion models or receptor models, or a combination (depending on the circumstances). Receptor models focus on the behavior of the ambient environment at the point of impact as opposed to source-oriented dispersion models, which focus on the transport, diffusion, and transformation that begin at the source and continue to the receptor site. Receptor models attempt to identify and apportion sources by relating known sample compositions at receptors to measured or inferred compositions of source emissions. When complete and accurate emission inventories or meteorological characterization are unavailable, or unknown pollutant sources exist, receptor modeling may be necessary.

i. Models for assessing the impact of CO emissions are needed for a number of different purposes. Examples include evaluating effects of point sources, congested intersections and highways, as well as the cumulative effect of numerous sources of CO in an urban area.

j. Models for assessing the impact of sources on ambient NO₂ concentrations are primarily needed to meet new source review requirements, such as addressing the effect of a proposed source on PSD increments for annual concentrations of NO₂. Impact of an individual source on ambient NO₂ depends, in part, on the chemical environment into which the source's plume is to be emitted. There are several approaches for estimating effects of an individual source on ambient NO₂. One approach is through use of a plume-in-grid algorithm imbedded within a photochemical grid model. However, because of the rigor and complexity involved, and because this approach may not be capable of defining sub-grid concentration gradients, the plume-in-grid approach may be impractical for estimating effects on an annual PSD increment. A second approach which does not have this limitation and accommodates distance-dependent conversion ratios—the Plume Volume Molar Ratio Method (PVMRM)³⁶—is currently being tested to determine suitability as a refined method. A third (screening) approach is to develop site specific (domain-wide) conversion factors based on measurements. If it is not possible

to develop site specific conversion factors and use of the plume-in-grid algorithm is also not feasible, other screening procedures may be considered.

k. In January 1999 (40 CFR Part 58, Appendix D), EPA gave notice that concern about ambient lead impacts was being shifted away from roadways and toward a focus on stationary point sources. EPA has also issued guidance on siting ambient monitors in the vicinity of such sources.³⁷ For lead, the SIP should contain an air quality analysis to determine the maximum quarterly lead concentration resulting from major lead point sources, such as smelters, gasoline additive plants, etc. General guidance for lead SIP development is also available.³⁸

5.2 Recommendations

5.2.1 Models for Ozone

a. *Choice of Models for Multi-source Applications.* Simulation of ozone formation and transport is a highly complex and resource intensive exercise. Control agencies with jurisdiction over areas with ozone problems are encouraged to use photochemical grid models, such as the Models-3/Community Multi-scale Air Quality (CMAQ) modeling system,³⁹ to evaluate the relationship between precursor species and ozone. Judgment on the suitability of a model for a given application should consider factors that include use of the model in an attainment test, development of emissions and meteorological inputs to the model and choice of episodes to model.³² Similar models for the 8-hour NAAQS and for the 1-hour NAAQS are appropriate.

b. *Choice of Models to Complement Photochemical Grid Models.* As previously noted, observational models, Lagrangian models, or the refined version of the Ozone Isopleth Plotting Program (OZIPR)⁴⁰ may be used to help guide choice of strategies to simulate with a photochemical grid model and to corroborate results obtained with a grid model. Receptor models have also been used to apportion sources of ozone precursors (*e.g.*, VOC) in urban domains. EPA has issued guidance³² in selecting appropriate techniques.

c. *Estimating the Impact of Individual Sources.* Choice of methods used to assess the impact of an individual source depends on the nature of the source and its emissions. Thus, model users should consult with the Regional Office to determine the most suitable approach on a case-by-case basis (subsection 3.2.2).

5.2.2 Models for Particulate Matter

5.2.2.1 PM-2.5

a. *Choice of Models for Multi-source Applications.* Simulation of phenomena resulting in high ambient PM-2.5 can be a multi-faceted

and complex problem resulting from PM-2.5's existence as an aerosol mixture. Treating secondary components of PM-2.5, such as sulfates and nitrates, can be a highly complex and resource-intensive exercise. Control agencies with jurisdiction over areas with secondary PM-2.5 problems are encouraged to use models which integrate chemical and physical processes important in the formation, decay and transport of these species (e.g., Models-3/CMAQ³⁸ or REMSAD⁴¹). Primary components can be simulated using less resource-intensive techniques. Suitability of a modeling approach or mix of modeling approaches for a given application requires technical judgement,³³ as well as professional experience in choice of models, use of the model(s) in an attainment test, development of emissions and meteorological inputs to the model and selection of days to model.

b. *Choice of Analysis Techniques to Complement Air Quality Simulation Models.* Receptor models may be used to corroborate predictions obtained with one or more air quality simulation models. They may also be potentially useful in helping to define specific source categories contributing to major components of PM-2.5.³³

c. *Estimating the Impact of Individual Sources.* Choice of methods used to assess the impact of an individual source depends on the nature of the source and its emissions. Thus, model users should consult with the Regional Office to determine the most suitable approach on a case-by-case basis (subsection 3.2.2).

5.2.2.2 PM-10

a. Screening techniques like those identified in subsection 4.2.1 are applicable to PM-10. Conservative assumptions which do not allow removal or transformation are suggested for screening. Thus, it is recommended that subjectively determined values for "half-life" or pollutant decay not be used as a surrogate for particle removal. Proportional models (rollback/forward) may not be applied for screening analysis, unless such techniques are used in conjunction with receptor modeling.³⁴

b. Refined models such as those discussed in subsection 4.2.2 are recommended for PM-10. However, where possible, particle size, gas-to-particle formation, and their effect on ambient concentrations may be considered. For point sources of small particles and for source-specific analyses of complicated sources, use the appropriate recommended steady-state plume dispersion model (subsection 4.2.2).

c. Receptor models have proven useful for helping validate emission inventories and for corroborating source-specific impacts estimated by dispersion models. The Chemical Mass Balance (CMB) model is useful for apportioning impacts from localized

sources.^{42,43,44} Other receptor models, e.g., the Positive Matrix Factorization (PMF) model⁴⁵ and Unmix,⁴⁶ which don't share some of CMB's constraints, have also been applied. In regulatory applications, dispersion models have been used in conjunction with receptor models to attribute source (or source category) contributions. Guidance is available for PM-10 sampling and analysis applicable to receptor modeling.⁴⁷

d. Under certain conditions, recommended dispersion models may not be reliable. In such circumstances, the modeling approach should be approved by the Regional Office on a case-by-case basis. Analyses involving model calculations for stagnation conditions should also be justified on a case-by-case basis (subsection 7.2.8).

e. Fugitive dust usually refers to dust put into the atmosphere by the wind blowing over plowed fields, dirt roads or desert or sandy areas with little or no vegetation. Re-entrained dust is that which is put into the air by reason of vehicles driving over dirt roads (or dirty roads) and dusty areas. Such sources can be characterized as line, area or volume sources. Emission rates may be based on site specific data or values from the general literature. Fugitive emissions include the emissions resulting from the industrial process that are not captured and vented through a stack but may be released from various locations within the complex. In some unique cases a model developed specifically for the situation may be needed. Due to the difficult nature of characterizing and modeling fugitive dust and fugitive emissions, it is recommended that the proposed procedure be cleared by the Regional Office for each specific situation before the modeling exercise is begun.

5.2.3 Models for Carbon Monoxide

a. Guidance is available for analyzing CO impacts at roadway intersections.⁴⁸ The recommended screening model for such analyses is CAL3QHC.^{49,50} This model combines CALINE3 (listed in Appendix A) with a traffic model to calculate delays and queues that occur at signalized intersections. The screening approach is described in reference 48; a refined approach may be considered on a case-by-case basis with CAL3QHCR.⁵¹ The latest version of the MOBILE (mobile source emission factor) model should be used for emissions input to intersection models.

b. For analyses of highways characterized by uninterrupted traffic flows, CALINE3 is recommended, with emissions input from the latest version of the MOBILE model. A scientific review article for line source models is available.⁵²

c. For urban area wide analyses of CO, an Eulerian grid model should be used. Information on SIP development and requirements for using such models can be found in several references.^{48,53,54,55}

d. Where point sources of CO are of concern, they should be treated using the screening and refined techniques described in Section 4.

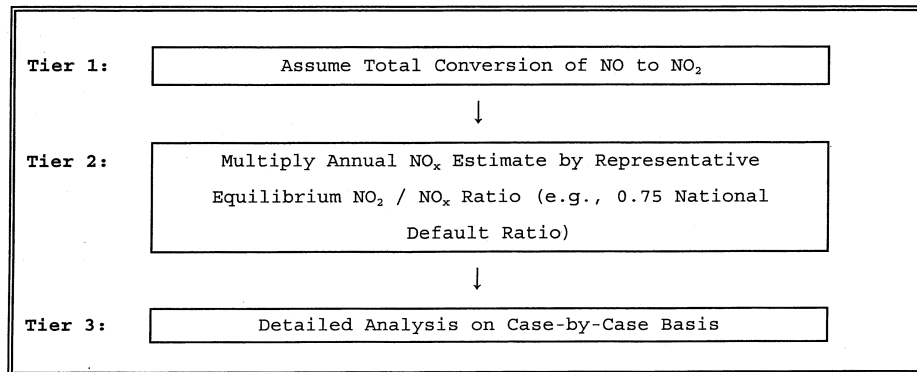
5.2.4 Models for Nitrogen Dioxide (Annual Average)

a. A tiered screening approach is recommended to obtain annual average estimates of NO₂ from point sources for New

Source Review analysis, including PSD, and for SIP planning purposes. This multi-tiered approach is conceptually shown in Figure 5-1 and described in paragraphs b through d of this subsection:

Figure 5-1

Multi-tiered screening approach for Estimating Annual NO₂ Concentrations from Point Sources



b. For Tier 1 (the initial screen), use an appropriate model in subsection 4.2.2 to estimate the maximum annual average concentration and assume a total conversion of NO to NO₂. If the concentration exceeds the NAAQS and/or PSD increments for NO₂, proceed to the 2nd level screen.

c. For Tier 2 (2nd level) screening analysis, multiply the Tier 1 estimate(s) by an empirically derived NO₂/NO_x value of 0.75 (annual national default).⁵⁶ The reviewing agency may establish an alternative default NO₂/NO_x ratio based on ambient annual average NO₂ and annual average NO_x data representative of area wide quasi-equilibrium conditions. Alternative default NO₂/NO_x ratios should be based on data satisfying quality assurance procedures that ensure data accuracy for both NO₂ and NO_x within the typical range of measured values. In areas with relatively low NO_x concentrations, the quality assurance procedures used to determine compliance with the NO₂ national ambient air quality standard may not be adequate. In addition, default NO₂/NO_x ratios, including the 0.75 national default value, can underestimate long range NO₂ impacts and should be used with caution in long range transport scenarios.

d. For Tier 3 (3rd level) analysis, a detailed screening method may be selected on a case-by-case basis. For point source modeling, detailed screening techniques such as the

Ozone Limiting Method⁵⁷ may also be considered. Also, a site specific NO₂/NO_x ratio may be used as a detailed screening method if it meets the same restrictions as described for alternative default NO₂/NO_x ratios. Ambient NO_x monitors used to develop a site specific ratio should be sited to obtain the NO₂ and NO_x concentrations under quasi-equilibrium conditions. Data obtained from monitors sited at the maximum NO_x impact site, as may be required in a PSD pre-construction monitoring program, likely reflect transitional NO_x conditions. Therefore, NO_x data from maximum impact sites may not be suitable for determining a site specific NO₂/NO_x ratio that is applicable for the entire modeling analysis. A site specific ratio derived from maximum impact data can only be used to estimate NO₂ impacts at receptors located within the same distance of the source as the source-to-monitor distance.

e. In urban areas (subsection 7.2.3), a proportional model may be used as a preliminary assessment to evaluate control strategies to meet the NAAQS for multiple minor sources, *i.e.*, minor point, area and mobile sources of NO_x; concentrations resulting from major point sources should be estimated separately as discussed above, then added to the impact of the minor sources. An acceptable screening technique for urban complexes is to assume that all NO_x is emitted in the form of NO₂ and to use a model

from Appendix A for nonreactive pollutants to estimate NO₂ concentrations. A more accurate estimate can be obtained by: (1) Calculating the annual average concentrations of NO_x with an urban model, and (2) converting these estimates to NO₂ concentrations using an empirically derived annual NO₂/NO_x ratio. A value of 0.75 is recommended for this ratio. However, a spatially averaged alternative default annual NO₂/NO_x ratio may be determined from an existing air quality monitoring network and used in lieu of the 0.75 value if it is determined to be representative of prevailing ratios in the urban area by the reviewing agency. To ensure use of appropriate locally derived annual average NO₂/NO_x ratios, monitoring data under consideration should be limited to those collected at monitors meeting siting criteria defined in 40 CFR Part 58, Appendix D as representative of “neighborhood”, “urban”, or “regional” scales. Furthermore, the highest annual spatially averaged NO₂/NO_x ratio from the most recent 3 years of complete data should be used to foster conservatism in estimated impacts.

f. To demonstrate compliance with NO₂ PSD increments in urban areas, emissions from major and minor sources should be included in the modeling analysis. Point and area source emissions should be modeled as discussed above. If mobile source emissions do not contribute to localized areas of high ambient NO₂ concentrations, they should be modeled as area sources. When modeled as area sources, mobile source emissions should be assumed uniform over the entire highway link and allocated to each area source grid square based on the portion of highway link within each grid square. If localized areas of high concentrations are likely, then mobile sources should be modeled as line sources using an appropriate steady-state plume dispersion model (*e.g.*, CAL3QHCR; subsection 5.2.3).

g. More refined techniques to handle special circumstances may be considered on a case-by-case basis and agreement with the appropriate reviewing authority (paragraph 3.0(b)) should be obtained. Such techniques should consider individual quantities of NO and NO₂ emissions, atmospheric transport and dispersion, and atmospheric transformation of NO to NO₂. Where they are available, site specific data on the conversion of NO to NO₂ may be used. Photochemical dispersion models, if used for other pollutants in the area, may also be applied to the NO_x problem.

5.2.5 Models for Lead

a. For major lead point sources, such as smelters, which contribute fugitive emissions and for which deposition is important, professional judgement should be used, and there should be coordination with the appro-

priate reviewing authority (paragraph 3.0(b)). To model an entire major urban area or to model areas without significant sources of lead emissions, as a minimum a proportional (rollback) model may be used for air quality analysis. The rollback philosophy assumes that measured pollutant concentrations are proportional to emissions. However, urban or other dispersion models are encouraged in these circumstances where the use of such models is feasible.

b. In modeling the effect of traditional line sources (such as a specific roadway or highway) on lead air quality, dispersion models applied for other pollutants can be used. Dispersion models such as CALINE3 and CAL3QHCR have been used for modeling carbon monoxide emissions from highways and intersections (subsection 5.2.3). Where there is a point source in the middle of a substantial road network, the lead concentrations that result from the road network should be treated as background (subsection 8.2); the point source and any nearby major roadways should be modeled separately using the appropriate recommended steady-state plume dispersion model (subsection 4.2.2).

6.0 OTHER MODEL REQUIREMENTS

6.1 Discussion

a. This section covers those cases where specific techniques have been developed for special regulatory programs. Most of the programs have, or will have when fully developed, separate guidance documents that cover the program and a discussion of the tools that are needed. The following paragraphs reference those guidance documents, when they are available. No attempt has been made to provide a comprehensive discussion of each topic since the reference documents were designed to do that. This section will undergo periodic revision as new programs are added and new techniques are developed.

b. Other Federal agencies have also developed specific modeling approaches for their own regulatory or other requirements.⁵⁸ Although such regulatory requirements and manuals may have come about because of EPA rules or standards, the implementation of such regulations and the use of the modeling techniques is under the jurisdiction of the agency issuing the manual or directive.

c. The need to estimate impacts at distances greater than 50km (the nominal distance to which EPA considers most steady-state Gaussian plume models are applicable) is an important one especially when considering the effects from secondary pollutants. Unfortunately, models originally available to EPA had not undergone sufficient field evaluation to be recommended for general use. Data bases from field studies at

mesoscale and long range transport distances were limited in detail. This limitation was a result of the expense to perform the field studies required to verify and improve mesoscale and long range transport models. Meteorological data adequate for generating three-dimensional wind fields were particularly sparse. Application of models to complicated terrain compounds the difficulty of making good assessments of long range transport impacts. EPA completed limited evaluation of several long range transport (LRT) models against two sets of field data and evaluated results.⁵⁹ Based on the results, EPA concluded that long range and mesoscale transport models were limited for regulatory use to a case-by-case basis. However a more recent series of comparisons has been completed for a new model, CALPUFF (Section A.3). Several of these field studies involved three-to-four hour releases of tracer gas sampled along arcs of receptors at distances greater than 50km downwind. In some cases, short-term concentration sampling was available, such that the transport of the tracer puff as it passed the arc could be monitored. Differences on the order of 10 to 20 degrees were found between the location of the simulated and observed center of mass of the tracer puff. Most of the simulated centerline concentration maxima along each arc were within a factor of two of those observed. It was concluded from these case studies that the CALPUFF dispersion model had performed in a reasonable manner, and had no apparent bias toward over or under prediction, so long as the transport distance was limited to less than 300km.⁶⁰

6.2 Recommendations

6.2.1 Visibility

a. Visibility in important natural areas (e.g., Federal Class I areas) is protected under a number of provisions of the Clean Air Act, including Sections 169A and 169B (addressing impacts primarily from existing sources) and Section 165 (new source review). Visibility impairment is caused by light scattering and light absorption associated with particles and gases in the atmosphere. In most areas of the country, light scattering by PM-2.5 is the most significant component of visibility impairment. The key components of PM-2.5 contributing to visibility impairment include sulfates, nitrates, organic carbon, elemental carbon, and crustal material.

b. The visibility regulations as promulgated in December 1980 (40 CFR 51.300-307) require States to mitigate visibility impairment, in any of the 156 mandatory Federal Class I areas, that is found to be "reasonably attributable" to a single source or a small group of sources. In 1985, EPA promulgated Federal Implementation Plans (FIPs) for

several States without approved visibility provisions in their SIPs. The IMPROVE (Interagency Monitoring for Protected Visual Environments) monitoring network, a cooperative effort between EPA, the States, and Federal land management agencies, was established to implement the monitoring requirements in these FIPs. Data has been collected by the IMPROVE network since 1988.

c. In 1999, EPA issued revisions to the 1980 regulations to address visibility impairment in the form of regional haze, which is caused by numerous, diverse sources (e.g., stationary, mobile, and area sources) located across a broad region (40 CFR 51.308-309). The state of relevant scientific knowledge has expanded significantly since the Clean Air Act Amendments of 1977. A number of studies and reports^{61,62} have concluded that long range transport (e.g., up to hundreds of kilometers) of fine particulate matter plays a significant role in visibility impairment across the country. Section 169A of the Act requires states to develop SIPs containing long-term strategies for remedying existing and preventing future visibility impairment in 156 mandatory Class I federal areas. In order to develop long-term strategies to address regional haze, many States will need to conduct regional-scale modeling of fine particulate concentrations and associated visibility impairment (e.g., light extinction and deciview metrics).

d. To calculate the potential impact of a plume of specified emissions for specific transport and dispersion conditions ("plume blight"), a screening model, VISCREEN, and guidance are available.⁶³ If a more comprehensive analysis is required, a refined model should be selected. The model selection (VISCREEN vs. PLUVUE II or some other refined model), procedures, and analyses should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the affected Federal Land Manager (FLM). FLMS are responsible for determining whether there is an adverse effect by a plume on a Class I area.

e. CALPUFF (Section A.3) may be applied when assessment is needed of reasonably attributable haze impairment or atmospheric deposition due to one or a small group of sources. This situation may involve more sources and larger modeling domains than that to which VISCREEN ideally may be applied. The procedures and analyses should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the affected FLM(s).

f. Regional scale models are used by EPA to develop and evaluate national policy and assist State and local control agencies. Two such models which can be used to assess visibility impacts from source emissions are Models-3/CMAQ³⁸ and REMSAD.⁴¹ Model

users should consult with the appropriate reviewing authority (paragraph 3.0(b)), which in this instance would include FLMs.

6.2.2 Good Engineering Practice Stack Height

a. The use of stack height credit in excess of Good Engineering Practice (GEP) stack height or credit resulting from any other dispersion technique is prohibited in the development of emission limitations by 40 CFR 51.118 and 40 CFR 51.164. The definitions of GEP stack height and dispersion technique are contained in 40 CFR 51.100. Methods and procedures for making the appropriate stack height calculations, determining stack height credits and an example of applying those techniques are found in several references^{64,65,66,67}, which provide a great deal of additional information for evaluating and describing building cavity and wake effects.

b. If stacks for new or existing major sources are found to be less than the height defined by EPA's refined formula for determining GEP height, then air quality impacts associated with cavity or wake effects due to the nearby building structures should be determined. The EPA refined formula height is defined as $H + 1.5L$ (see reference 66). Detailed downwash screening procedures²⁴ for both the cavity and wake regions should be followed. If more refined concentration estimates are required, the recommended steady-state plume dispersion model in subsection 4.2.2 contains algorithms for building wake calculations and should be used.

6.2.3 Long Range Transport (LRT) (*i.e.*, Beyond 50km)

a. Section 165(d) of the Clean Air Act requires that suspected adverse impacts on PSD Class I areas be determined. However, 50km is the useful distance to which most steady-state Gaussian plume models are considered accurate for setting emission limits. Since in many cases PSD analyses show that Class I areas may be threatened at distances greater than 50km from new sources, some procedure is needed to (1) determine if an adverse impact will occur, and (2) identify the model to be used in setting an emission limit if the Class I increments are threatened. In addition to the situations just described, there are certain applications containing a mixture of both long range and short range source-receptor relationships in a large modeled domain (*e.g.*, several industrialized areas located along a river or valley). Historically, these applications have presented considerable difficulty to an analyst if impacts from sources having transport distances greater than 50km significantly contributed to the design concentrations. To properly analyze applications of this type, a modeling approach is needed which has the capability of combining, in a consistent

manner, impacts involving both short and long range transport. The CALPUFF modeling system, listed in Appendix A, has been designed to accommodate both the Class I area LRT situation and the large modeling domain situation. Given the judgement and refinement involved, conducting a LRT modeling assessment will require significant consultation with the appropriate reviewing authority (paragraph 3.0(b)) and the affected FLM(s). The FLM has an affirmative responsibility to protect air quality related values (AQRVs) that may be affected, and to provide the appropriate procedures and analysis techniques. Where there is no increment violation, the ultimate decision on whether a Class I area is adversely affected is the responsibility of the appropriate reviewing authority (Section 165(d)(2)(C)(ii) of the Clean Air Act), taking into consideration any information on the impacts on AQRVs provided by the FLM. According to Section 165(d)(2)(C)(iii) of the Clean Air Act, if there is a Class I increment violation, the *source* must demonstrate to the satisfaction of the FLM that the emissions from the source will have no adverse impact on the AQRVs.

b. If LRT is determined to be important, then refined estimates utilizing the CALPUFF modeling system should be obtained. A screening approach^{60,68} is also available for use on a case-by-case basis that generally provides concentrations that are higher than those obtained using refined characterizations of the meteorological conditions. The meteorological input data requirements for developing the time and space varying three-dimensional winds and dispersion meteorology for refined analyses are discussed in paragraph 8.3.1.2(d). Additional information on applying this model is contained in Appendix A. To facilitate use of complex air quality and meteorological modeling systems, a written protocol approved by the appropriate reviewing authority (paragraph 3.0(b)) and the affected FLM(s) may be considered for developing consensus in the methods and procedures to be followed.

6.2.4 Modeling Guidance for Other Governmental Programs

a. When using the models recommended or discussed in the *Guideline* in support of programmatic requirements not specifically covered by EPA regulations, the model user should consult the appropriate Federal or State agency to ensure the proper application and use of the models. For modeling associated with PSD permit applications that involve a Class I area, the appropriate Federal Land Manager should be consulted on all modeling questions.

b. The Offshore and Coastal Dispersion (OCD) model, described in Appendix A, was developed by the Minerals Management

Service and is recommended for estimating air quality impact from offshore sources on onshore, flat terrain areas. The OCD model is not recommended for use in air quality impact assessments for onshore sources. Sources located on or just inland of a shoreline where fumigation is expected should be treated in accordance with subsection 7.2.8.

c. The latest version of the Emissions and Dispersion Modeling System (EDMS), was developed and is supported by the Federal Aviation Administration (FAA), and is appropriate for air quality assessment of primary pollutant impacts at airports or air bases. EDMS has adopted AERMOD for treating dispersion. Application of EDMS is intended for estimating the collective impact of changes in aircraft operations, point source, and mobile source emissions on pollutant concentrations. It is not intended for PSD, SIP, or other regulatory air quality analyses of point or mobile sources at or peripheral to airport property that are unrelated to airport operations. If changes in other than aircraft operations are associated with analyses, a model recommended in Chapter 4 or 5 should be used. The latest version of EDMS may be obtained from FAA at its Web site: <http://www.aee.faa.gov/emissions/edms/edms/home.htm>.

7.0 GENERAL MODELING CONSIDERATIONS

7.1 Discussion

a. This section contains recommendations concerning a number of different issues not explicitly covered in other sections of this guide. The topics covered here are not specific to any one program or modeling area but are common to nearly all modeling analyses for criteria pollutants.

7.2 Recommendations

7.2.1 Design Concentrations (See Also Subsection 10.2.3.1)

7.2.1.1 Design Concentrations for SO₂, PM-10, CO, Pb, and NO₂

a. An air quality analysis for SO₂, PM-10, CO, Pb, and NO₂ is required to determine if the source will (1) cause a violation of the NAAQS, or (2) cause or contribute to air quality deterioration greater than the specified allowable PSD increment. For the former, background concentration (subsection 8.2) should be added to the estimated impact of the source to determine the design concentration. For the latter, the design concentration includes impact from all increment consuming sources.

b. If the air quality analyses are conducted using the period of meteorological input data recommended in subsection 8.3.1.2 (e.g., 5 years of National Weather Service (NWS) data or at least 1 year of site specific data; subsection 8.3.3), then the design concentra-

tion based on the highest, second-highest short term concentration over the entire receptor network for each year modeled or the highest long term average (whichever is controlling) should be used to determine emission limitations to assess compliance with the NAAQS and PSD increments. For the 24-hour PM-10 NAAQS (which is a probabilistic standard)—when multiple years are modeled, they collectively represent a single period. Thus, if 5 years of NWS data are modeled, then the highest sixth highest concentration for the whole period becomes the design value. And in general, when *n* years are modeled, the (*n*+1)th highest concentration over the *n*-year period is the design value, since this represents an average or expected exceedance rate of one per year.

c. When sufficient and representative data exist for less than a 5-year period from a nearby NWS site, or when site specific data have been collected for less than a full continuous year, or when it has been determined that the site specific data may not be temporally representative (subsection 8.3.3), then the highest concentration estimate should be considered the design value. This is because the length of the data record may be too short to assure that the conditions producing worst-case estimates have been adequately sampled. The highest value is then a surrogate for the concentration that is not to be exceeded more than once per year (the wording of the deterministic standards). Also, the highest concentration should be used whenever selected worst-case conditions are input to a screening technique, as described in EPA guidance.²⁴

d. If the controlling concentration is an annual average value and multiple years of data (site specific or NWS) are used, then the design value is the highest of the annual averages calculated for the individual years. If the controlling concentration is a quarterly average and multiple years are used, then the highest individual quarterly average should be considered the design value.

e. As long a period of record as possible should be used in making estimates to determine design values and PSD increments. If more than 1 year of site specific data is available, it should be used.

7.2.1.2 Design Concentrations for O₃ and PM-2.5

a. Guidance and specific instructions for the determination of the 1-hr and 8-hr design concentrations for ozone are provided in Appendix H and I (respectively) of reference 4. Appendix H explains how to determine when the expected number of days per calendar year with maximum hourly concentrations above the NAAQS is equal to or less than 1. Appendix I explains the data handling conventions and computations necessary for determining whether the 8-hour primary and secondary NAAQS are met at an ambient

monitoring site. For PM-2.5, Appendix N of reference 4, and supplementary guidance,⁶⁹ explain the data handling conventions and computations necessary for determining when the annual and 24-hour primary and secondary NAAQS are met. For all SIP revisions the user should check with the Regional Office to obtain the most recent guidance documents and policy memoranda concerning the pollutant in question. There are currently no PSD increments for O₃ and PM-2.5.

7.2.2 Critical Receptor Sites

a. Receptor sites for refined modeling should be utilized in sufficient detail to estimate the highest concentrations and possible violations of a NAAQS or a PSD increment. In designing a receptor network, the emphasis should be placed on receptor resolution and location, not total number of receptors. The selection of receptor sites should be a case-by-case determination taking into consideration the topography, the climatology, monitor sites, and the results of the initial screening procedure.

7.2.3 Dispersion Coefficients

a. Steady-state Gaussian plume models used in most applications should employ dispersion coefficients consistent with those contained in the preferred models in Appendix A. Factors such as averaging time, urban/rural surroundings (*see* paragraphs (b)—(f) of this subsection), and type of source (point vs. line) may dictate the selection of specific coefficients. Coefficients used in some Appendix A models are identical to, or at least based on, Pasquill-Gifford coefficients⁷⁰ in rural areas and McElroy-Pooler⁷¹ coefficients in urban areas. A key feature of AERMOD's formulation is the use of directly observed variables of the boundary layer to parameterize dispersion.²²

b. The selection of either rural or urban dispersion coefficients in a specific application should follow one of the procedures suggested by Irwin⁷² and briefly described in paragraphs (c)—(f) of this subsection. These include a land use classification procedure or a population based procedure to determine whether the character of an area is primarily urban or rural.

c. Land Use Procedure: (1) Classify the land use within the total area, A_o, circumscribed by a 3km radius circle about the source using the meteorological land use typing scheme proposed by Auer⁷³; (2) if land use types I1, I2, C1, R2, and R3 account for 50 percent or more of A_o, use urban dispersion coefficients; otherwise, use appropriate rural dispersion coefficients.

d. Population Density Procedure: (1) Compute the average population density, \bar{p} per square kilometer with A_o as defined above; (2) If \bar{p} is greater than 750 people/km², use

urban dispersion coefficients; otherwise use appropriate rural dispersion coefficients.

e. Of the two methods, the land use procedure is considered more definitive. Population density should be used with caution and should not be applied to highly industrialized areas where the population density may be low and thus a rural classification would be indicated, but the area is sufficiently built-up so that the urban land use criteria would be satisfied. In this case, the classification should already be "urban" and urban dispersion parameters should be used.

f. Sources located in an area defined as urban should be modeled using urban dispersion parameters. Sources located in areas defined as rural should be modeled using the rural dispersion parameters. For analyses of whole urban complexes, the entire area should be modeled as an urban region if most of the sources are located in areas classified as urban.

g. Buoyancy-induced dispersion (BID), as identified by Pasquill⁷⁴, is included in the preferred models and should be used where buoyant sources, *e.g.*, those involving fuel combustion, are involved.

7.2.4 Stability Categories

a. The Pasquill approach to classifying stability is commonly used in preferred models (Appendix A). The Pasquill method, as modified by Turner⁷⁵, was developed for use with commonly observed meteorological data from the National Weather Service and is based on cloud cover, insolation and wind speed.

b. Procedures to determine Pasquill stability categories from other than NWS data are found in subsection 8.3. Any other method to determine Pasquill stability categories must be justified on a case-by-case basis.

c. For a given model application where stability categories are the basis for selecting dispersion coefficients, both σ_y and σ_z should be determined from the same stability category. "Split sigmas" in that instance are not recommended. Sector averaging, which eliminates the σ_y term, is commonly acceptable in complex terrain screening methods.

d. AERMOD, also a preferred model in Appendix A, uses a planetary boundary layer scaling parameter to characterize stability.²² This approach represents a departure from the discrete, hourly stability categories estimated under the Pasquill-Gifford-Turner scheme.

7.2.5 Plume Rise

a. The plume rise methods of Briggs^{76,77} are incorporated in many of the preferred models and are recommended for use in many modeling applications. In AERMOD,²² for the stable boundary layer, plume rise is estimated using an iterative approach, similar

to that in the CTDMPLUS model. In the convective boundary layer, plume rise is superposed on the displacements by random convective velocities.⁷⁸ In AERMOD, plume rise is computed using the methods of Briggs excepting cases involving building downwash, in which a numerical solution of the mass, energy, and momentum conservation laws is performed.²³ No explicit provisions in these models are made for multistack plume rise enhancement or the handling of such special plumes as flares; these problems should be considered on a case-by-case basis.

b. Gradual plume rise is generally recommended where its use is appropriate: (1) In AERMOD; (2) in complex terrain screening procedures to determine close-in impacts and (3) when calculating the effects of building wakes. The building wake algorithm in AERMOD incorporates and exercises the thermodynamically based gradual plume rise calculations as described in (a) above. If the building wake is calculated to affect the plume for any hour, gradual plume rise is also used in downwind dispersion calculations to the distance of final plume rise, after which final plume rise is used. Plumes captured by the near wake are re-emitted to the far wake as a ground-level volume source.

c. Stack tip downwash generally occurs with poorly constructed stacks and when the ratio of the stack exit velocity to wind speed is small. An algorithm developed by Briggs⁷⁷ is the recommended technique for this situation and is used in preferred models for point sources.

7.2.6 Chemical Transformation

a. The chemical transformation of SO₂ emitted from point sources or single industrial plants in rural areas is generally assumed to be relatively unimportant to the estimation of maximum concentrations when travel time is limited to a few hours. However, in urban areas, where synergistic effects among pollutants are of considerable consequence, chemical transformation rates may be of concern. In urban area applications, a half-life of 4 hours⁷⁵ may be applied to the analysis of SO₂ emissions. Calculations of transformation coefficients from site specific studies can be used to define a "half-life" to be used in a steady-state Gaussian plume model with any travel time, or in any application, if appropriate documentation is provided. Such conversion factors for pollutant half-life should not be used with screening analyses.

b. Use of models incorporating complex chemical mechanisms should be considered only on a case-by-case basis with proper demonstration of applicability. These are generally regional models not designed for the evaluation of individual sources but used primarily for region-wide evaluations. Visi-

bility models also incorporate chemical transformation mechanisms which are an integral part of the visibility model itself and should be used in visibility assessments.

7.2.7 Gravitational Settling and Deposition

a. An "infinite half-life" should be used for estimates of particle concentrations when steady-state Gaussian plume models containing only exponential decay terms for treating settling and deposition are used.

b. Gravitational settling and deposition may be directly included in a model if either is a significant factor. When particulate matter sources can be quantified and settling and dry deposition are problems, professional judgement should be used, and there should be coordination with the appropriate reviewing authority (paragraph 3.0(b)).

7.2.8 Complex Winds

a. *Inhomogeneous Local Winds.* In many parts of the United States, the ground is neither flat nor is the ground cover (or land use) uniform. These geographical variations can generate local winds and circulations, and modify the prevailing ambient winds and circulations. Geographic effects are most apparent when the ambient winds are light or calm.⁷⁹ In general these geographically induced wind circulation effects are named after the source location of the winds, *e.g.*, lake and sea breezes, and mountain and valley winds. In very rugged hilly or mountainous terrain, along coastlines, or near large land use variations, the characterization of the winds is a balance of various forces, such that the assumptions of steady-state straight-line transport both in time and space are inappropriate. In the special cases described, the CALPUFF modeling system (described in Appendix A) may be applied on a case-by-case basis for air quality estimates in such complex non-steady-state meteorological conditions. The purpose of choosing a modeling system like CALPUFF is to fully treat the time and space variations of meteorology effects on transport and dispersion. The setup and application of the model should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) consistent with limitations of paragraph 3.2.2(e). The meteorological input data requirements for developing the time and space varying three-dimensional winds and dispersion meteorology for these situations are discussed in paragraphs 8.3.1.2(d) and 8.3.1.2(f). Examples of inhomogeneous winds include, but aren't limited to, situations described in the following paragraphs (i)–(iii):

i. *Inversion Breakup Fumigation.* Inversion breakup fumigation occurs when a plume (or multiple plumes) is emitted into a stable layer of air and that layer is subsequently mixed to the ground through convective

transfer of heat from the surface or because of advection to less stable surroundings. Fumigation may cause excessively high concentrations but is usually rather short-lived at a given receptor. There are no recommended refined techniques to model this phenomenon. There are, however, screening procedures²⁴ that may be used to approximate the concentrations. Considerable care should be exercised in using the results obtained from the screening techniques.

ii. *Shoreline Fumigation.* Fumigation can be an important phenomenon on and near the shoreline of bodies of water. This can affect both individual plumes and area-wide emissions. When fumigation conditions are expected to occur from a source or sources with tall stacks located on or just inland of a shoreline, this should be addressed in the air quality modeling analysis. The Shoreline Dispersion Model (SDM) listed on EPA's Internet SCRAM Web site (subsection 2.3) may be applied on a case-by-case basis when air quality estimates under shoreline fumigation conditions are needed.⁸⁰ Information on the results of EPA's evaluation of this model together with other coastal fumigation models is available.⁸¹ Selection of the appropriate model for applications where shoreline fumigation is of concern should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

iii. *Stagnation.* Stagnation conditions are characterized by calm or very low wind speeds, and variable wind directions. These stagnant meteorological conditions may persist for several hours to several days. During stagnation conditions, the dispersion of air pollutants, especially those from low-level emissions sources, tends to be minimized, potentially leading to relatively high ground-level concentrations. If point sources are of interest, users should note the guidance provided for CALPUFF in paragraph (a) of this subsection. Selection of the appropriate model for applications where stagnation is of concern should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

7.2.9 Calibration of Models

a. Calibration of models is not common practice and is subject to much error and misunderstanding. There have been attempts by some to compare model estimates and measurements on an event-by-event basis and then to calibrate a model with results of that comparison. This approach is severely limited by uncertainties in both source and meteorological data and therefore it is difficult to precisely estimate the concentration at an exact location for a specific increment of time. Such uncertainties make calibration of models of questionable benefit. Therefore, model calibration is unacceptable.

8.0 MODEL INPUT DATA

a. Data bases and related procedures for estimating input parameters are an integral part of the modeling procedure. The most appropriate data available should always be selected for use in modeling analyses. Concentrations can vary widely depending on the source data or meteorological data used. Input data are a major source of uncertainties in any modeling analysis. This section attempts to minimize the uncertainty associated with data base selection and use by identifying requirements for data used in modeling. A checklist of input data requirements for modeling analyses is posted on EPA's Internet SCRAM Web site (subsection 2.3). More specific data requirements and the format required for the individual models are described in detail in the users' guide for each model.

8.1 Source Data

8.1.1 Discussion

a. Sources of pollutants can be classified as point, line and area/volume sources. Point sources are defined in terms of size and may vary between regulatory programs. The line sources most frequently considered are roadways and streets along which there are well-defined movements of motor vehicles, but they may be lines of roof vents or stacks such as in aluminum refineries. Area and volume sources are often collections of a multitude of minor sources with individually small emissions that are impractical to consider as separate point or line sources. Large area sources are typically treated as a grid network of square areas, with pollutant emissions distributed uniformly within each grid square.

b. Emission factors are compiled in an EPA publication commonly known as AP-42;⁸² an indication of the quality and amount of data on which many of the factors are based is also provided. Other information concerning emissions is available in EPA publications relating to specific source categories. The appropriate reviewing authority (paragraph 3.0(b)) should be consulted to determine appropriate source definitions and for guidance concerning the determination of emissions from and techniques for modeling the various source types.

8.1.2 Recommendations

a. For point source applications the load or operating condition that causes maximum ground-level concentrations should be established. As a minimum, the source should be modeled using the design capacity (100 percent load). If a source operates at greater than design capacity for periods that could result in violations of the standards or PSD

increments, this load)^a should be modeled. Where the source operates at substantially less than design capacity, and the changes in the stack parameters associated with the operating conditions could lead to higher ground level concentrations, loads such as 50 percent and 75 percent of capacity should also be modeled. A range of operating conditions should be considered in screening analyses; the load causing the highest concentration, in addition to the design load, should be included in refined modeling. For a steam power plant, the following (b-h) is typical of the kind of data on source characteristics and operating conditions that may be needed. Generally, input data requirements for air quality models necessitate the use of metric units; where English units are common for engineering usage, a conversion to metric is required.

b. *Plant layout.* The connection scheme between boilers and stacks, and the distance and direction between stacks, building parameters (length, width, height, location and orientation relative to stacks) for plant structures which house boilers, control equipment, and surrounding buildings within a distance of approximately five stack heights.

c. *Stack parameters.* For all stacks, the stack height and inside diameter (meters), and the temperature (K) and volume flow rate (actual cubic meters per second) or exit gas velocity (meters per second) for operation at 100 percent, 75 percent and 50 percent load.

d. *Boiler size.* For all boilers, the associated megawatts, 10⁶ BTU/hr, and pounds of steam per hour, and the design and/or actual fuel consumption rate for 100 percent load for coal (tons/hour), oil (barrels/hour), and natural gas (thousand cubic feet/hour).

e. *Boiler parameters.* For all boilers, the percent excess air used, the boiler type (e.g., wet bottom, cyclone, etc.), and the type of firing (e.g., pulverized coal, front firing, etc.).

f. *Operating conditions.* For all boilers, the type, amount and pollutant contents of fuel, the total hours of boiler operation and the boiler capacity factor during the year, and the percent load for peak conditions.

g. *Pollution control equipment parameters.* For each boiler served and each pollutant affected, the type of emission control equipment, the year of its installation, its design

efficiency and mass emission rate, the date of the last test and the tested efficiency, the number of hours of operation during the latest year, and the best engineering estimate of its projected efficiency if used in conjunction with coal combustion; data for any anticipated modifications or additions.

h. *Data for new boilers or stacks.* For all new boilers and stacks under construction and for all planned modifications to existing boilers or stacks, the scheduled date of completion, and the data or best estimates available for items (b) through (g) of this subsection following completion of construction or modification.

i. In stationary point source applications for compliance with short term ambient standards, SIP control strategies should be tested using the emission input shown on Table 8-1. When using a refined model, sources should be modeled sequentially with these loads for every hour of the year. To evaluate SIPs for compliance with quarterly and annual standards, emission input data shown in Table 8-1 should again be used. Emissions from area sources should generally be based on annual average conditions. The source input information in each model user's guide should be carefully consulted and the checklist (paragraph 8.0(a)) should also be consulted for other possible emission data that could be helpful. NAAQS compliance demonstrations in a PSD analysis should follow the emission input data shown in Table 8-2. For purposes of emissions trading, new source review and demonstrations, refer to current EPA policy and guidance to establish input data.

j. Line source modeling of streets and highways requires data on the width of the roadway and the median strip, the types and amounts of pollutant emissions, the number of lanes, the emissions from each lane and the height of emissions. The location of the ends of the straight roadway segments should be specified by appropriate grid coordinates. Detailed information and data requirements for modeling mobile sources of pollution are provided in the user's manuals for each of the models applicable to mobile sources.

k. The impact of growth on emissions should be considered in all modeling analyses covering existing sources. Increases in emissions due to planned expansion or planned fuel switches should be identified. Increases in emissions at individual sources that may be associated with a general industrial/commercial/residential expansion in multi-source urban areas should also be treated. For new sources the impact of growth on emissions should generally be considered for the period prior to the start-up date for the source. Such changes in emissions should treat increased area source emissions, changes in existing point source emissions which were not subject to

^aMalfunctions which may result in excess emissions are not considered to be a normal operating condition. They generally should not be considered in determining allowable emissions. However, if the excess emissions are the result of poor maintenance, careless operation, or other preventable conditions, it may be necessary to consider them in determining source impact.

preconstruction review, and emissions due to sources with permits to construct that have not yet started operation.

TABLE 8–1—MODEL EMISSION INPUT DATA FOR POINT SOURCES ¹

| Averaging time | Emission limit (#/MMBtu) ² | × | Operating level (MMBtu/hr) ² | × | Operating factor (e.g., hr/yr, hr/day) |
|---|--|---|---|---|---|
| Stationary Point Source(s) Subject to SIP Emission Limit(s) Evaluation for Compliance with Ambient Standards (Including Areawide Demonstrations) | | | | | |
| Annual & quarterly | Maximum allowable emission limit or federally enforceable permit limit. | | Actual or design capacity (whichever is greater), or federally enforceable permit condition. | | Actual operating factor averaged over most recent 2 years. ³ |
| Short term | Maximum allowable emission limit or federally enforceable permit limit. | | Actual or design capacity (whichever is greater), or federally enforceable permit condition. ⁴ | | Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base). ⁵ |
| Nearby Source(s) ^{6,7} | | | | | |
| Same input requirements as for stationary point source(s) above. | | | | | |
| Other Source(s) ⁷ | | | | | |
| If modeled (subsection 8.2.3), input data requirements are defined below. | | | | | |
| Annual & quarterly | Maximum allowable emission limit or federally enforceable permit limit. ⁶ | | Annual level when actually operating, averaged over the most recent 2 years. ³ | | Actual operating factor averaged over the most recent 2 years. ³ |
| Short term | Maximum allowable emission limit or federally enforceable permit limit. ⁶ | | Annual level when actually operating, averaged over the most recent 2 years. ³ | | Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base). ⁵ |

¹ The model input data requirements shown on this table apply to stationary source control strategies for STATE IMPLEMENTATION PLANS. For purposes of emissions trading, new source review, or prevention of significant deterioration, other model input criteria may apply. Refer to the policy and guidance for these programs to establish the input data.

² Terminology applicable to fuel burning sources; analogous terminology (e.g., #/throughput) may be used for other types of sources.

³ Unless it is determined that this period is not representative.

⁴ Operating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration.

⁵ If operation does not occur for all hours of the time period of consideration (e.g., 3 or 24 hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (e.g., if operation is only 8 a.m. to 4 p.m. each day, only these hours will be modeled with emissions from the source. Modeled emissions should not be averaged across non-operating time periods.)

⁶ See paragraph 8.2.3(c).

⁷ See paragraph 8.2.3(d).

TABLE 8–2—POINT SOURCE MODEL EMISSION INPUT DATA FOR NAAQS COMPLIANCE IN PSD DEMONSTRATIONS

| Averaging time | Emission limit (#/MMBtu) ¹ | × | Operating level (MMBtu/hr) ¹ | × | Operating factor (e.g., hr/yr, hr/day) |
|--|--|---|--|---|---|
| Proposed Major New or Modified Source | | | | | |
| Annual & quarterly | Maximum allowable emission limit or federally enforceable permit limit. | | Design capacity or federally enforceable permit condition. | | Continuous operation (i.e., 8760 hours). ² |
| Short term (≤ 24 hours) | Maximum allowable emission limit or federally enforceable permit limit. | | Design capacity or federally enforceable permit condition. ³ | | Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base). ² |
| Nearby Source(s) ^{4,5} | | | | | |
| Annual & quarterly | Maximum allowable emission limit or federally enforceable permit limit. ⁵ | | Actual or design capacity (whichever is greater), or federally enforceable permit condition. | | Actual operating factor averaged over the most recent 2 years. ^{7,8} |

TABLE 8-2—POINT SOURCE MODEL EMISSION INPUT DATA FOR NAAQS COMPLIANCE IN PSD DEMONSTRATIONS—Continued

| Averaging time | Emission limit (#/MMBtu) ¹ | × | Operating level (MMBtu/hr) ¹ | × | Operating factor (e.g., hr/yr, hr/day) |
|--------------------------------------|--|---|---|---|---|
| Short term (≤ 24 hours) | Maximum allowable emission limit or federally enforceable permit limit. ⁵ | | Actual or design capacity (whichever is greater), or federally enforceable permit condition. ³ | | Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base). ² |
| Other Source(s)^{6,9} | | | | | |
| Annual & quarterly | Maximum allowable emission limit or federally enforceable permit limit. ⁵ | | Annual level when actually operating, averaged over the most recent 2 years. ⁷ | | Actual operating factor averaged over the most recent 2 years. ^{7,8} |
| Short term (≤ 24 hours) | Maximum allowable emission limit or federally enforceable permit limit. ⁵ | | Annual level when actually operating, averaged over the most recent 2 years. ⁷ | | Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base). ² |

¹Terminology applicable to fuel burning sources; analogous terminology (e.g., #/throughput) may be used for other types of sources.

²If operation does not occur for all hours of the time period of consideration (e.g., 3 or 24 hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (e.g., if operation is only 8 a.m. to 4 p.m. each day, only these hours will be modeled with emissions from the source. Modeled emissions should not be averaged across non-operating time periods.

³Operating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration.

⁴Includes existing facility to which modification is proposed if the emissions from the existing facility will not be affected by the modification. Otherwise use the same parameters as for major modification.

⁵See paragraph 8.2.3(c).

⁶See paragraph 8.2.3(d).

⁷Unless it is determined that this period is not representative.

⁸For those permitted sources not in operation or that have not established an appropriate factor, continuous operation (i.e., 8760) should be used.

⁹Generally, the ambient impacts from non-nearby (background) sources can be represented by air quality data unless adequate data do not exist.

8.2 Background Concentrations

8.2.1 Discussion

a. Background concentrations are an essential part of the total air quality concentration to be considered in determining source impacts. Background air quality includes pollutant concentrations due to: (1) Natural sources; (2) nearby sources other than the one(s) currently under consideration; and (3) unidentified sources.

b. Typically, air quality data should be used to establish background concentrations in the vicinity of the source(s) under consideration. The monitoring network used for background determinations should conform to the same quality assurance and other requirements as those networks established for PSD purposes.⁸³ An appropriate data validation procedure should be applied to the data prior to use.

c. If the source is not isolated, it may be necessary to use a multi-source model to establish the impact of nearby sources. Since sources don't typically operate at their maximum allowable capacity (which may include the use of "dirtier" fuels), modeling is necessary to express the potential contribution of background sources, and this impact would not be captured via monitoring. Back-

ground concentrations should be determined for each critical (concentration) averaging time.

8.2.2 Recommendations (Isolated Single Source)

a. Two options (paragraph (b) or (c) of this section) are available to determine the background concentration near isolated sources.

b. Use air quality data collected in the vicinity of the source to determine the background concentration for the averaging times of concern. Determine the mean background concentration at each monitor by excluding values when the source in question is impacting the monitor. The mean annual background is the average of the annual concentrations so determined at each monitor. For shorter averaging periods, the meteorological conditions accompanying the concentrations of concern should be identified. Concentrations for meteorological conditions of concern, at monitors not impacted by the source in question, should be averaged for each separate averaging time to determine the average background value. Monitoring sites inside a 90° sector downwind of the source may be used to determine the area of impact. One hour concentrations may

be added and averaged to determine longer averaging periods.

c. If there are no monitors located in the vicinity of the source, a “regional site” may be used to determine background. A “regional site” is one that is located away from the area of interest but is impacted by similar natural and distant man-made sources.

8.2.3 Recommendations (Multi-Source Areas)

a. In multi-source areas, two components of background should be determined: contributions from nearby sources and contributions from other sources.

b. *Nearby Sources:* All sources expected to cause a significant concentration gradient in the vicinity of the source or sources under consideration for emission limit(s) should be explicitly modeled. The number of such sources is expected to be small except in unusual situations. Owing to both the uniqueness of each modeling situation and the large number of variables involved in identifying nearby sources, no attempt is made here to comprehensively define this term. Rather, identification of nearby sources calls for the exercise of professional judgement by the appropriate reviewing authority (paragraph 3.0(b)). This guidance is not intended to alter the exercise of that judgement or to comprehensively define which sources are nearby sources.

c. For compliance with the short-term and annual ambient standards, the nearby sources as well as the primary source(s) should be evaluated using an appropriate Appendix A model with the emission input data shown in Table 8-1 or 8-2. When modeling a nearby source that does not have a permit and the emission limit contained in the SIP for a particular source category is greater than the emissions possible given the source’s maximum physical capacity to emit, the “maximum allowable emission limit” for such a nearby source may be calculated as the emission rate representative of the nearby source’s maximum physical capacity to emit, considering its design specifications and allowable fuels and process materials. However, the burden is on the permit applicant to sufficiently document what the maximum physical capacity to emit is for such a nearby source.

d. It is appropriate to model nearby sources only during those times when they, by their nature, operate at the same time as the primary source(s) being modeled. Where a primary source believes that a nearby source does not, by its nature, operate at the same time as the primary source being modeled, the burden is on the primary source to demonstrate to the satisfaction of the appropriate reviewing authority (paragraph 3.0(b)) that this is, in fact, the case. Whether or not the primary source has adequately demonstrated that fact is a matter of profes-

sional judgement left to the discretion of the appropriate reviewing authority. The following examples illustrate two cases in which a nearby source may be shown not to operate at the same time as the primary source(s) being modeled. Some sources are only used during certain seasons of the year. Those sources would not be modeled as nearby sources during times in which they do not operate. Similarly, emergency backup generators that never operate simultaneously with the sources that they back up would not be modeled as nearby sources. To reiterate, in these examples and other appropriate cases, the burden is on the primary source being modeled to make the appropriate demonstration to the satisfaction of the appropriate reviewing authority.

e. The impact of the nearby sources should be examined at locations where interactions between the plume of the point source under consideration and those of nearby sources (plus natural background) can occur. Significant locations include: (1) the area of maximum impact of the point source; (2) the area of maximum impact of nearby sources; and (3) the area where all sources combine to cause maximum impact. These locations may be identified through trial and error analyses.

f. *Other Sources:* That portion of the background attributable to all other sources (*e.g.*, natural sources, minor sources and distant major sources) should be determined by the procedures found in subsection 89.2.2 or by application of a model using Table 8-1 or 8-2.

8.3 Meteorological Input Data

a. The meteorological data used as input to a dispersion model should be selected on the basis of spatial and climatological (temporal) representativeness as well as the ability of the individual parameters selected to characterize the transport and dispersion conditions in the area of concern. The representativeness of the data is dependent on: (1) The proximity of the meteorological monitoring site to the area under consideration; (2) the complexity of the terrain; (3) the exposure of the meteorological monitoring site; and (4) the period of time during which data are collected. The spatial representativeness of the data can be adversely affected by large distances between the source and receptors of interest and the complex topographic characteristics of the area. Temporal representativeness is a function of the year-to-year variations in weather conditions. Where appropriate, data representativeness should be viewed in terms of the appropriateness of the data for constructing realistic boundary layer profiles and three dimensional meteorological fields, as described in paragraphs (c) and (d) below.

b. Model input data are normally obtained either from the National Weather Service or

as part of a site specific measurement program. Local universities, Federal Aviation Administration (FAA), military stations, industry and pollution control agencies may also be sources of such data. Some recommendations for the use of each type of data are included in this subsection.

c. Regulatory application of AERMOD requires careful consideration of minimum data for input to AERMET. Data representativeness, in the case of AERMOD, means utilizing data of an appropriate type for constructing realistic boundary layer profiles. Of paramount importance is the requirement that all meteorological data used as input to AERMOD must be both laterally and vertically representative of the transport and dispersion within the analysis domain. Where surface conditions vary significantly over the analysis domain, the emphasis in assessing representativeness should be given to adequate characterization of transport and dispersion between the source(s) of concern and areas where maximum design concentrations are anticipated to occur. The representativeness of data that were collected off-site should be judged, in part, by comparing the surface characteristics in the vicinity of the meteorological monitoring site with the surface characteristics that generally describe the analysis domain. The surface characteristics input to AERMET should be based on the topographic conditions in the vicinity of the meteorological tower. Furthermore, since the spatial scope of each variable could be different, representativeness should be judged for each variable separately. For example, for a variable such as wind direction, the data may need to be collected very near plume height to be adequately representative, whereas, for a variable such as temperature, data from a station several kilometers away from the source may in some cases be considered to be adequately representative.

d. For long range transport modeling assessments (subsection 6.2.3) or for assessments where the transport winds are complex and the application involves a non-steady-state dispersion model (subsection 7.2.8), use of output from prognostic mesoscale meteorological models is encouraged.^{84,85,86} Some diagnostic meteorological processors are designed to appropriately blend available NWS comparable meteorological observations, local site specific meteorological observations, and prognostic mesoscale meteorological data, using empirical relationships, to diagnostically adjust the wind field for mesoscale and local-scale effects. These diagnostic adjustments can sometimes be improved through the use of strategically placed site specific meteorological observations. The placement of these special meteorological observations (often more than one location is needed) involves expert judgement, and is specific to the ter-

rain and land use of the modeling domain. Acceptance for use of output from prognostic mesoscale meteorological models is contingent on concurrence by the appropriate reviewing authorities (paragraph 3.0(b)) that the data are of acceptable quality, which can be demonstrated through statistical comparisons with observations of winds aloft and at the surface at several appropriate locations.

8.3.1 Length of Record of Meteorological Data

8.3.1.1 Discussion

a. The model user should acquire enough meteorological data to ensure that worst-case meteorological conditions are adequately represented in the model results. The trend toward statistically based standards suggests a need for all meteorological conditions to be adequately represented in the data set selected for model input. The number of years of record needed to obtain a stable distribution of conditions depends on the variable being measured and has been estimated by Landsberg and Jacobs⁸⁷ for various parameters. Although that study indicates in excess of 10 years may be required to achieve stability in the frequency distributions of some meteorological variables, such long periods are not reasonable for model input data. This is due in part to the fact that hourly data in model input format are frequently not available for such periods and that hourly calculations of concentration for long periods may be prohibitively expensive. Another study⁸⁸ compared various periods from a 17-year data set to determine the minimum number of years of data needed to approximate the concentrations modeled with a 17-year period of meteorological data from one station. This study indicated that the variability of model estimates due to the meteorological data input was adequately reduced if a 5-year period of record of meteorological input was used.

8.3.1.2 Recommendations

a. Five years of representative meteorological data should be used when estimating concentrations with an air quality model. Consecutive years from the most recent, readily available 5-year period are preferred. The meteorological data should be *adequately representative*, and may be site specific or from a nearby NWS station. Where professional judgment indicates NWS-collected ASOS (automated surface observing stations) data are inadequate {for cloud cover observations}, the most recent 5 years of NWS data that are observer-based may be considered for use.

b. The use of 5 years of NWS meteorological data or at least 1 year of site specific

data is required. If one year or more (including partial years), up to five years, of site specific data is available, these data are preferred for use in air quality analyses. Such data should have been subjected to quality assurance procedures as described in subsection 8.3.3.2.

c. For permitted sources whose emission limitations are based on a specific year of meteorological data, that year should be added to any longer period being used (*e.g.*, 5 years of NWS data) when modeling the facility at a later time.

d. For LRT situations (subsection 6.2.3) and for complex wind situations (paragraph 7.2.8(a)), if only NWS or comparable standard meteorological observations are employed, five years of meteorological data (within and near the modeling domain) should be used. Consecutive years from the most recent, readily available 5-year period are preferred. Less than five, but at least three, years of meteorological data (need not be consecutive) may be used if mesoscale meteorological fields are available, as discussed in paragraph 8.3(d). These mesoscale meteorological fields should be used in conjunction with available standard NWS or comparable meteorological observations within and near the modeling domain.

e. For solely LRT applications (subsection 6.2.3), if site specific meteorological data are available, these data may be helpful when used in conjunction with available standard NWS or comparable observations and mesoscale meteorological fields as described in paragraph 8.3.1.2(d).

f. For complex wind situations (paragraph 7.2.8(a)) where site specific meteorological data are being relied upon as the basis for characterizing the meteorological conditions, a data base of at least 1 full-year of meteorological data is required. If more data are available, they should be used. Site specific meteorological data may have to be collected at multiple locations. Such data should have been subjected to quality assurance procedures as described in paragraph 8.3.3.2(a), and should be reviewed for spatial and temporal representativeness.

8.3.2 National Weather Service Data

8.3.2.1 Discussion

a. The NWS meteorological data are routinely available and familiar to most model users. Although the NWS does not provide direct measurements of all the needed dispersion model input variables, methods have been developed and successfully used to translate the basic NWS data to the needed model input. Site specific measurements of model input parameters have been made for many modeling studies, and those methods and techniques are becoming more widely applied, especially in situations such as complex terrain applications, where available

NWS data are not adequately representative. However, there are many model applications where NWS data are adequately representative, and the applications still rely heavily on the NWS data.

b. Many models use the standard hourly weather observations available from the National Climatic Data Center (NCDC). These observations are then preprocessed before they can be used in the models.

8.3.2.2 Recommendations

a. The preferred models listed in Appendix A all accept as input the NWS meteorological data preprocessed into model compatible form. If NWS data are judged to be adequately representative for a particular modeling application, they may be used. NCDC makes available surface^{89,90} and upper air⁹¹ meteorological data in CD-ROM format.

b. Although most NWS measurements are made at a standard height of 10 meters, the actual anemometer height should be used as input to the preferred model. Note that AERMOD at a minimum requires wind observations at a height above ground between seven times the local surface roughness height and 100 meters.

c. Wind directions observed by the National Weather Service are reported to the nearest 10 degrees. A specific set of randomly generated numbers has been developed for use with the preferred EPA models and should be used with NWS data to ensure a lack of bias in wind direction assignments within the models.

d. Data from universities, FAA, military stations, industry and pollution control agencies may be used if such data are equivalent in accuracy and detail to the NWS data, and they are judged to be adequately representative for the particular application.

8.3.3 Site Specific Data

8.3.3.1 Discussion

a. Spatial or geographical representativeness is best achieved by collection of all of the needed model input data in close proximity to the actual site of the source(s). Site specific measured data are therefore preferred as model input, provided that appropriate instrumentation and quality assurance procedures are followed and that the data collected are adequately representative (free from inappropriate local or microscale influences) and compatible with the input requirements of the model to be used. It should be noted that, while site specific measurements are frequently made “on-property” (*i.e.*, on the source’s premises), acquisition of adequately representative site specific data does not preclude collection of data from a location off property. Conversely, collection of meteorological data on a source’s property

does not of itself guarantee adequate representativeness. For help in determining representativeness of site specific measurements, technical guidance⁹² is available. Site specific data should always be reviewed for representativeness and consistency by a qualified meteorologist.

8.3.3.2 Recommendations

a. EPA guidance⁹² provides recommendations on the collection and use of site specific meteorological data. Recommendations on characteristics, siting, and exposure of meteorological instruments and on data recording, processing, completeness requirements, reporting, and archiving are also included. This publication should be used as a supplement to other limited guidance on these subjects.^{83,93,94} Detailed information on quality assurance is also available.⁹⁵ As a minimum, site specific measurements of ambient air temperature, transport wind speed and direction, and the variables necessary to estimate atmospheric dispersion should be available in meteorological data sets to be used in modeling. Care should be taken to ensure that meteorological instruments are located to provide representative characterization of pollutant transport between sources and receptors of interest. The appropriate reviewing authority (paragraph 3.0(b)) is available to help determine the appropriateness of the measurement locations.

b. All site specific data should be reduced to hourly averages. Table 8-3 lists the wind related parameters and the averaging time requirements.

c. *Missing Data Substitution.* After valid data retrieval requirements have been met,⁹² hours in the record having missing data should be treated according to an established data substitution protocol provided that data from an adequately representative alternative site are available. Such protocols are usually part of the approved monitoring program plan. Data substitution guidance is provided in Section 5.3 of reference 92. If no representative alternative data are available for substitution, the absent data should be coded as missing using missing data codes appropriate to the applicable meteorological pre-processor. Appropriate model options for treating missing data, if available in the model, should be employed.

d. *Solar Radiation Measurements.* Total solar radiation or net radiation should be measured with a reliable pyranometer or net radiometer, sited and operated in accordance with established site specific meteorological guidance.^{92,95}

e. *Temperature Measurements.* Temperature measurements should be made at standard shelter height (2m) in accordance with established site specific meteorological guidance.⁹²

f. *Temperature Difference Measurements.* Temperature difference (ΔT) measurements

should be obtained using matched thermometers or a reliable thermocouple system to achieve adequate accuracy. Siting, probe placement, and operation of ΔT systems should be based on guidance found in Chapter 3 of reference 92, and such guidance should be followed when obtaining vertical temperature gradient data. AERMET employs the Bulk Richardson scheme which requires measurements of temperature difference. To ensure correct application and acceptance, AERMOD users should consult with the appropriate Reviewing Authority before using the Bulk Richardson scheme for their analysis.

g. *Winds Aloft.* For simulation of plume rise and dispersion of a plume emitted from a stack, characterization of the wind profile up through the layer in which the plume disperses is required. This is especially important in complex terrain and/or complex wind situations where wind measurements at heights up to hundreds of meters above stack base may be required in some circumstances. For tall stacks when site specific data are needed, these winds have been obtained traditionally using meteorological sensors mounted on tall towers. A feasible alternative to tall towers is the use of meteorological remote sensing instruments (e.g., acoustic sounders or radar wind profilers) to provide winds aloft, coupled with 10-meter towers to provide the near-surface winds. (For specific requirements for AERMOD and CTDMPPLUS, see Appendix A.) Specifications for wind measuring instruments and systems are contained in reference 92.

h. *Turbulence.* There are several dispersion models that are capable of using direct measurements of turbulence (wind fluctuations) in the characterization of the vertical and lateral dispersion (e.g., CTDMPPLUS, AERMOD, and CALPUFF). For specific requirements for CTDMPPLUS, AERMOD, and CALPUFF, see Appendix A. For technical guidance on measurement and processing of turbulence parameters, see reference 92. When turbulence data are used in this manner to directly characterize the vertical and lateral dispersion, the averaging time for the turbulence measurements should be one hour (Table 8-3). There are other dispersion models (e.g., BLP, and CALINE3) that employ P-G stability categories for the characterization of the vertical and lateral dispersion. Methods for using site specific turbulence data for the characterization of P-G stability categories are discussed in reference 92. When turbulence data are used in this manner to determine the P-G stability category, the averaging time for the turbulence measurements should be 15 minutes.

i. *Stability Categories.* For dispersion models that employ P-G stability categories for the characterization of the vertical and lateral dispersion, the P-G stability categories, as

originally defined, couple near-surface measurements of wind speed with subjectively determined insolation assessments based on hourly cloud cover and ceiling height observations. The wind speed measurements are made at or near 10m. The insolation rate is typically assessed using observations of cloud cover and ceiling height based on criteria outlined by Turner.⁷⁰ It is recommended that the P-G stability category be estimated using the Turner method with site specific wind speed measured at or near 10m and representative cloud cover and ceiling height. Implementation of the Turner method, as well as considerations in determining representativeness of cloud cover and ceiling height in cases for which site specific cloud observations are unavailable, may be found in Section 6 of reference 92. In the absence of requisite data to implement the Turner method, the SRDT method or wind fluctuation statistics (i.e., the σ_E and σ_A methods) may be used.

j. The SRDT method, described in Section 6.4.4.2 of reference 92, is modified slightly from that published from earlier work⁹⁶ and has been evaluated with three site specific data bases.⁹⁷ The two methods of stability classification which use wind fluctuation statistics, the σ_E and σ_A methods, are also described in detail in Section 6.4.4 of reference 92 (note applicable tables in Section 6). For additional information on the wind fluctuation methods, several references are available.^{98,99,100,101}

k. *Meteorological Data Preprocessors.* The following meteorological preprocessors are recommended by EPA: AERMET,¹⁰² PCRAMMET,¹⁰³ MPRM,¹⁰⁴ METPRO,¹⁰⁵ and CALMET.¹⁰⁶ AERMET, which is patterned after MPRM, should be used to preprocess all data for use with AERMOD. Except for applications that employ AERMOD, PCRAMMET is the recommended meteorological preprocessor for use in applications employing hourly NWS data. MPRM is a general purpose meteorological data preprocessor which supports regulatory models requiring PCRAMMET formatted (NWS) data. MPRM is available for use in applications employing site specific meteorological data. The latest version (MPRM 1.3) has been configured to implement the SRDT method for estimating P-G stability categories. METPRO is the required meteorological data preprocessor for use with CTDMPPLUS. CALMET is available for use with applications of CALPUFF. All of the above mentioned data preprocessors are available for downloading from EPA's Internet SCRAM Web site (subsection 2.3).

TABLE 8–3—AVERAGING TIMES FOR SITE SPECIFIC WIND AND TURBULENCE MEASUREMENTS

| Parameter | Averaging time (hour) |
|---|-----------------------|
| Surface wind speed (for use in stability determinations) | 1 |
| Transport direction | 1 |
| Dilution wind speed | 1 |
| Turbulence measurements (σ_E and σ_A) for use in stability determinations | 1 ¹ |
| Turbulence measurements for direct input to dispersion models | 1 |

¹To minimize meander effects in σ_A when wind conditions are light and/or variable, determine the hourly average σ value from four sequential 15-minute σ 's according to the following formula:

$$\sigma_{1-hr} = \sqrt{\frac{\sigma_{15}^2 + \sigma_{15}^2 + \sigma_{15}^2 + \sigma_{15}^2}{4}}$$

8.3.4 Treatment of Near-Calms and Calms

8.3.4.1 Discussion

a. Treatment of calm or light and variable wind poses a special problem in model applications since steady-state Gaussian plume models assume that concentration is inversely proportional to wind speed. Furthermore, concentrations may become unrealistically large when wind speeds less than 1 m/s are input to the model. Procedures have been developed to prevent the occurrence of overly conservative concentration estimates during periods of calms. These procedures acknowledge that a steady-state Gaussian plume model does not apply during calm conditions, and that our knowledge of wind patterns and plume behavior during these conditions does not, at present, permit the development of a better technique. Therefore, the procedures disregard hours which are identified as calm. The hour is treated as missing and a convention for handling missing hours is recommended.

b. AERMOD, while fundamentally a steady-state Gaussian plume model, contains algorithms for dealing with low wind speed (near calm) conditions. As a result, AERMOD can produce model estimates for conditions when the wind speed may be less than 1 m/s, but still greater than the instrument threshold. Required input to AERMET, the meteorological processor for AERMOD, includes a threshold wind speed and a reference wind speed. The threshold wind speed is typically the threshold of the instrument used to collect the wind speed data. The reference wind speed is selected by the model as the lowest level of non-missing wind speed and direction data where the speed is greater than the wind speed threshold, and the height of the measurement is between seven times the local surface roughness and 100 meters. If the only valid observation of the

reference wind speed between these heights is less than the threshold, the hour is considered calm, and no concentration is calculated. None of the observed wind speeds in a measured wind profile that are less than the threshold speed are used in construction of the modeled wind speed profile in AERMOD.

8.3.4.2 Recommendations

a. Hourly concentrations calculated with steady-state Gaussian plume models using calms should not be considered valid; the wind and concentration estimates for these hours should be disregarded and considered to be missing. Critical concentrations for 3-, 8-, and 24-hour averages should be calculated by dividing the sum of the hourly concentrations for the period by the number of valid or non-missing hours. If the total number of valid hours is less than 18 for 24-hour averages, less than 6 for 8-hour averages or less than 3 for 3-hour averages, the total concentration should be divided by 18 for the 24-hour average, 6 for the 8-hour average and 3 for the 3-hour average. For annual averages, the sum of all valid hourly concentrations is divided by the number of non-calm hours during the year. AERMOD has been coded to implement these instructions. For models listed in Appendix A, a post-processor computer program, CALMPRO¹⁰⁷ has been prepared, is available on the SCRAM Internet Web site (subsection 2.3), and should be used.

b. Stagnant conditions that include extended periods of calms often produce high concentrations over wide areas for relatively long averaging periods. The standard steady-state Gaussian plume models are often not applicable to such situations. When stagnation conditions are of concern, other modeling techniques should be considered on a case-by-case basis (see also subsection 7.2.8).

c. When used in steady-state Gaussian plume models, measured site specific wind speeds of less than 1 m/s but higher than the response threshold of the instrument should be input as 1 m/s; the corresponding wind direction should also be input. Wind observations below the response threshold of the instrument should be set to zero, with the input file in ASCII format. For input to AERMOD, no adjustment should be made to the site specific wind data. In all cases involving steady-state Gaussian plume models, calm hours should be treated as missing, and concentrations should be calculated as in paragraph (a) of this subsection.

9.0 ACCURACY AND UNCERTAINTY OF MODELS

9.1 Discussion

a. Increasing reliance has been placed on concentration estimates from models as the primary basis for regulatory decisions concerning source permits and emission control

requirements. In many situations, such as review of a proposed source, no practical alternative exists. Therefore, there is an obvious need to know how accurate models really are and how any uncertainty in the estimates affects regulatory decisions. During the 1980's, attempts were made to encourage development of standardized evaluation methods.^{11,108} EPA recognized the need for incorporating such information and has sponsored workshops¹⁰⁹ on model accuracy, the possible ways to quantify accuracy, and on considerations in the incorporation of model accuracy and uncertainty in the regulatory process. The Second (EPA) Conference on Air Quality Modeling, August 1982¹¹⁰, was devoted to that subject.

b. To better deduce the statistical significance of differences seen in model performance in the face of unaccounted for uncertainties and variations, investigators have more recently explored the use of bootstrap techniques.^{111,112} Work is underway to develop a new generation of evaluation metrics¹⁶ that takes into account the statistical differences (in error distributions) between model predictions and observations.¹¹³ Even though the procedures and measures are still evolving to describe performance of models that characterize atmospheric fate, transport and diffusion,^{114,115,116} there has been general acceptance of a need to address the uncertainties inherent in atmospheric processes.

9.1.1 Overview of Model Uncertainty

a. Dispersion models generally attempt to estimate concentrations at specific sites that really represent an ensemble average of numerous repetitions of the same event.¹⁶ The event is characterized by measured or "known" conditions that are input to the models, *e.g.*, wind speed, mixed layer height, surface heat flux, emission characteristics, etc. However, in addition to the known conditions, there are unmeasured or unknown variations in the conditions of this event, *e.g.*, unresolved details of the atmospheric flow such as the turbulent velocity field. These unknown conditions, may vary among repetitions of the event. As a result, deviations in observed concentrations from their ensemble average, and from the concentrations estimated by the model, are likely to occur even though the known conditions are fixed. Even with a *perfect model* that predicts the correct ensemble average, there are likely to be deviations from the observed concentrations in individual repetitions of the event, due to variations in the unknown conditions. The statistics of these concentration residuals are termed "inherent" uncertainty. Available evidence suggests that this source of uncertainty alone may be responsible for a typical range of variation in concentrations of as much as ± 50 percent.¹¹⁷

b. Moreover, there is “reducible” uncertainty¹⁰⁸ associated with the model and its input conditions; neither models nor data bases are perfect. Reducible uncertainties are caused by: (1) Uncertainties in the input values of the known conditions (*i.e.*, emission characteristics and meteorological data); (2) errors in the measured concentrations which are used to compute the concentration residuals; and (3) inadequate model physics and formulation. The “reducible” uncertainties can be minimized through better (more accurate and more representative) measurements and better model physics.

c. To use the terminology correctly, reference to model accuracy should be limited to that portion of reducible uncertainty which deals with the physics and the formulation of the model. The accuracy of the model is normally determined by an evaluation procedure which involves the comparison of model concentration estimates with measured air quality data.¹¹⁸ The statement of accuracy is based on statistical tests or performance measures such as bias, noise, correlation, etc.¹¹ However, information that allows a distinction between contributions of the various elements of inherent and reducible uncertainty is only now beginning to emerge.¹⁶ As a result most discussions of the accuracy of models make no quantitative distinction between (1) limitations of the model versus (2) limitations of the data base and of knowledge concerning atmospheric variability. The reader should be aware that statements on model accuracy and uncertainty may imply the need for improvements in model performance that even the “perfect” model could not satisfy.

9.1.2 Studies of Model Accuracy

a. A number of studies^{119,120} have been conducted to examine model accuracy, particularly with respect to the reliability of short-term concentrations required for ambient standard and increment evaluations. The results of these studies are not surprising. Basically, they confirm what expert atmospheric scientists have said for some time: (1) Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and (2) the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ± 10 to 40 percent are found to be typical,^{121,122} *i.e.*, certainly well within the often quoted factor-of-two accuracy that has long been recognized for these models. However, estimates of concentrations that occur at a specific time and site, are poorly correlated with actually observed concentrations and are much less reliable.

b. As noted above, poor correlations between paired concentrations at fixed stations may be due to “reducible” uncertainties in knowledge of the precise plume location and to unquantified inherent uncertainties. For example, Pasquill¹²³ estimates that, apart from data input errors, maximum ground-level concentrations at a given hour for a point source in flat terrain could be in error by 50 percent due to these uncertainties. Uncertainty of five to 10 degrees in the measured wind direction, which transports the plume, can result in concentration errors of 20 to 70 percent for a particular time and location, depending on stability and station location. Such uncertainties do not indicate that an estimated concentration does not occur, only that the precise time and locations are in doubt.

9.1.3 Use of Uncertainty in Decision-Making

a. The accuracy of model estimates varies with the model used, the type of application, and site specific characteristics. Thus, it is desirable to quantify the accuracy or uncertainty associated with concentration estimates used in decision-making. Communications between modelers and decision-makers must be fostered and further developed. Communications concerning concentration estimates currently exist in most cases, but the communications dealing with the accuracy of models and its meaning to the decision-maker are limited by the lack of a technical basis for quantifying and directly including uncertainty in decisions. Procedures for quantifying and interpreting uncertainty in the practical application of such concepts are only beginning to evolve; much study is still required.^{108,109,110,124,125}

b. In all applications of models an effort is encouraged to identify the reliability of the model estimates for that particular area and to determine the magnitude and sources of error associated with the use of the model. The analyst is responsible for recognizing and quantifying limitations in the accuracy, precision and sensitivity of the procedure. Information that might be useful to the decision-maker in recognizing the seriousness of potential air quality violations includes such model accuracy estimates as accuracy of peak predictions, bias, noise, correlation, frequency distribution, spatial extent of high concentration, etc. Both space/time pairing of estimates and measurements and unpaired comparisons are recommended. Emphasis should be on the highest concentrations and the averaging times of the standards or increments of concern. Where possible, confidence intervals about the statistical values should be provided. However, while such information can be provided by the modeler to

the decision-maker, it is unclear how this information should be used to make an air pollution control decision. Given a range of possible outcomes, it is easiest and tends to ensure consistency if the decision-maker confines his judgement to use of the "best estimate" provided by the modeler (*i.e.*, the design concentration estimated by a model recommended in the *Guideline* or an alternate model of known accuracy). This is an indication of the practical limitations imposed by current abilities of the technical community.

c. To improve the basis for decision-making, EPA has developed and is continuing to study procedures for determining the accuracy of models, quantifying the uncertainty, and expressing confidence levels in decisions that are made concerning emissions controls.^{126,127} However, work in this area involves "breaking new ground" with slow and sporadic progress likely. As a result, it may be necessary to continue using the "best estimate" until sufficient technical progress has been made to meaningfully implement such concepts dealing with uncertainty.

9.1.4 Evaluation of Models

a. A number of actions have been taken to ensure that the best model is used correctly for each regulatory application and that a model is not arbitrarily imposed. First, the *Guideline* clearly recommends the most appropriate model be used in each case. Preferred models, based on a number of factors, are identified for many uses. General guidance on using alternatives to the preferred models is also provided. Second, the models have been subjected to a systematic performance evaluation and a peer scientific review. Statistical performance measures, including measures of difference (or residuals) such as bias, variance of difference and gross variability of the difference, and measures of correlation such as time, space, and time and space combined as recommended by the AMS Woods Hole Workshop,¹¹ were generally followed. Third, more specific information has been provided for justifying the site specific use of alternative models in previously cited EPA guidance,¹⁵ and new models are under consideration and review.¹⁶ Together these documents provide methods that allow a judgement to be made as to what models are most appropriate for a specific application. For the present, performance and the theoretical evaluation of models are being used as an indirect means to quantify one element of uncertainty in air pollution regulatory decisions.

b. EPA has participated in a series of conferences entitled, "Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes."¹²⁸ for the purpose of promoting the development of improved methods for the characterization of model per-

formance. There is a consensus developing on what should be considered in the evaluation of air quality models¹²⁹, namely quality assurance planning, documentation and scrutiny should be consistent with the intended use, and should include:

- Scientific peer review;
- Supportive analyses (diagnostic evaluations, code verification, sensitivity and uncertainty analyses);
- Diagnostic and performance evaluations with data obtained in trial locations, and
- Statistical performance evaluations in the circumstances of the intended applications.

Performance evaluations and diagnostic evaluations assess different qualities of how well a model is performing, and both are needed to establish credibility within the client and scientific community. Performance evaluations allow us to decide how well the model simulates the average temporal and spatial patterns seen in the observations, and employ large spatial/temporal scale data sets (*e.g.*, national data sets). Performance evaluations also allow determination of relative performance of a model in comparison with alternative modeling systems. Diagnostic evaluations allow determination of a model capability to simulate individual processes that affect the results, and usually employ smaller spatial/temporal scale data sets (*e.g.*, field studies). Diagnostic evaluations allow us to decide if we get the right answer for the right reason. The objective comparison of modeled concentrations with observed field data provides only a partial means for assessing model performance. Due to the limited supply of evaluation data sets, there are severe practical limits in assessing model performance. For this reason, the conclusions reached in the science peer reviews and the supportive analyses have particular relevance in deciding whether a model will be useful for its intended purposes.

c. To extend information from diagnostic and performance evaluations, sensitivity and uncertainty analyses are encouraged since they can provide additional information on the effect of inaccuracies in the data bases and on the uncertainty in model estimates. Sensitivity analyses can aid in determining the effect of inaccuracies of variations or uncertainties in the data bases on the range of likely concentrations. Uncertainty analyses can aid in determining the range of likely concentration values, resulting from uncertainties in the model inputs, the model formulations, and parameterizations. Such information may be used to determine source impact and to evaluate control strategies. Where possible, information from such sensitivity analyses should be made available to the decision-maker with an appropriate interpretation of the effect on the critical concentrations.

9.2 Recommendations

a. No specific guidance on the quantification of model uncertainty for use in decision-making is being given at this time. As procedures for considering uncertainty develop and become implementable, this guidance will be changed and expanded. For the present, continued use of the “best estimate” is acceptable; however, in specific circumstances for O₃, PM-2.5 and regional haze, additional information and/or procedures may be appropriate.^{32,33}

10.0 REGULATORY APPLICATION OF MODELS

10.1 Discussion

a. Procedures with respect to the review and analysis of air quality modeling and data analyses in support of SIP revisions, PSD permitting or other regulatory requirements need a certain amount of standardization to ensure consistency in the depth and comprehensiveness of both the review and the analysis itself. This section recommends procedures that permit some degree of standardization while at the same time allowing the flexibility needed to assure the technically best analysis for each regulatory application.

b. Dispersion model estimates, especially with the support of measured air quality data, are the preferred basis for air quality demonstrations. Nevertheless, there are instances where the performance of recommended dispersion modeling techniques, by comparison with observed air quality data, may be shown to be less than acceptable. Also, there may be no recommended modeling procedure suitable for the situation. In these instances, emission limitations may be established solely on the basis of observed air quality data as would be applied to a modeling analysis. The same care should be given to the analyses of the air quality data as would be applied to a modeling analysis.

c. The current NAAQS for SO₂ and CO are both stated in terms of a concentration not to be exceeded more than once a year. There is only an annual standard for NO₂ and a quarterly standard for Pb. Standards for fine particulate matter (PM-2.5) are expressed in terms of both long-term (annual) and short-term (daily) averages. The long-term standard is calculated using the three year average of the annual averages while the short-term standard is calculated using the three year average of the 98th percentile of the daily average concentration. For PM-10, the convention is to compare the arithmetic mean, averaged over 3 consecutive years, with the concentration specified in the NAAQS (50 µg/m³). The 24-hour NAAQS (150 µg/m³) is met if, over a 3-year period, there is (on average) no more than one exceedance per year. As noted in subsection 7.2.1.1, the

modeled compliance for this NAAQS is based on the highest 6th highest concentration over 5 years. For ozone the short term 1-hour standard is expressed in terms of an expected exceedance limit while the short term 8-hour standard is expressed in terms of a three year average of the annual fourth highest daily maximum 8-hour value. The NAAQS are subjected to extensive review and possible revision every 5 years.

d. This section discusses general requirements for concentration estimates and identifies the relationship to emission limits. The following recommendations apply to: (1) Revisions of State Implementation Plans and (2) the review of new sources and the prevention of significant deterioration (PSD).

10.2 Recommendations

10.2.1 Analysis Requirements

a. Every effort should be made by the Regional Office to meet with all parties involved in either a SIP revision or a PSD permit application prior to the start of any work on such a project. During this meeting, a protocol should be established between the preparing and reviewing parties to define the procedures to be followed, the data to be collected, the model to be used, and the analysis of the source and concentration data. An example of requirements for such an effort is contained in the Air Quality Analysis Checklist posted on EPA's Internet SCRAM Web site (subsection 2.3). This checklist suggests the level of detail required to assess the air quality resulting from the proposed action. Special cases may require additional data collection or analysis and this should be determined and agreed upon at this preapplication meeting. The protocol should be written and agreed upon by the parties concerned, although a formal legal document is not intended. Changes in such a protocol are often required as the data collection and analysis progresses. However, the protocol establishes a common understanding of the requirements.

b. An air quality analysis should begin with a screening model to determine the potential of the proposed source or control strategy to violate the PSD increment or NAAQS. For traditional stationary sources, EPA guidance²⁴ should be followed. Guidance is also available for mobile sources.⁴⁸

c. If the concentration estimates from screening techniques indicate a significant impact or that the PSD increment or NAAQS may be approached or exceeded, then a more refined modeling analysis is appropriate and the model user should select a model according to recommendations in Sections 4–8. In some instances, no refined technique may be specified in this guide for the situation. The model user is then encouraged to submit a model developed specifically for

the case at hand. If that is not possible, a screening technique may supply the needed results.

d. Regional Offices should require permit applicants to incorporate the pollutant contributions of all sources into their analysis. Where necessary this may include emissions associated with growth in the area of impact of the new or modified source. PSD air quality assessments should consider the amount of the allowable air quality increment that has already been consumed by other sources. Therefore, the most recent source applicant should model the existing or permitted sources in addition to the one currently under consideration. This would permit the use of newly acquired data or improved modeling techniques if such have become available since the last source was permitted. When remodeling, the worst case used in the previous modeling analysis should be one set of conditions modeled in the new analysis. All sources should be modeled for each set of meteorological conditions selected.

10.2.2 Use of Measured Data in Lieu of Model Estimates

a. Modeling is the preferred method for determining emission limitations for both new and existing sources. When a preferred model is available, model results alone (including background) are sufficient. Monitoring will normally not be accepted as the sole basis for emission limitation. In some instances when the modeling technique available is only a screening technique, the addition of air quality data to the analysis may lend credence to model results.

b. There are circumstances where there is no applicable model, and measured data may need to be used. However, only in the case of a NAAQS assessment for an existing source should monitoring data alone be a basis for emission limits. In addition, the following items (i-vi) should be considered prior to the acceptance of the measured data:

- i. Does a monitoring network exist for the pollutants and averaging times of concern?
- ii. Has the monitoring network been designed to locate points of maximum concentration?
- iii. Do the monitoring network and the data reduction and storage procedures meet EPA monitoring and quality assurance requirements?
- iv. Do the data set and the analysis allow impact of the most important individual sources to be identified if more than one source or emission point is involved?
- v. Is at least one full year of valid ambient data available?
- vi. Can it be demonstrated through the comparison of monitored data with model results that available models are not applicable?

c. The number of monitors required is a function of the problem being considered.

The source configuration, terrain configuration, and meteorological variations all have an impact on number and placement of monitors. Decisions can only be made on a case-by-case basis. Guidance is available for establishing criteria for demonstrating that a model is not applicable?

d. Sources should obtain approval from the appropriate reviewing authority (paragraph 3.0(b)) for the monitoring network prior to the start of monitoring. A monitoring protocol agreed to by all concerned parties is highly desirable. The design of the network, the number, type and location of the monitors, the sampling period, averaging time as well as the need for meteorological monitoring or the use of mobile sampling or plume tracking techniques, should all be specified in the protocol and agreed upon prior to start-up of the network.

10.2.3 Emission Limits

10.2.3.1 Design Concentrations

a. Emission limits should be based on concentration estimates for the averaging time that results in the most stringent control requirements. The concentration used in specifying emission limits is called the design value or design concentration and is a sum of the concentration contributed by the primary source, other applicable sources, and—for NAAQS assessments—the background concentration.

b. To determine the averaging time for the design value, the most restrictive NAAQS or PSD increment, as applicable, should be identified. For a NAAQS assessment, the averaging time for the design value is determined by calculating, for each averaging time, the ratio of the difference between the applicable NAAQS (S) and the background concentration (B) to the (model) predicted concentration (P) (*i.e.*, $(S-B)/P$). For a PSD increment assessment, the averaging time for the design value is determined by calculating, for each averaging time, the ratio of the applicable PSD increment (I) and the model-predicted concentration (P) (*i.e.*, I/P). The averaging time with the lowest ratio identifies the most restrictive standard or increment. If the annual average is the most restrictive, the highest estimated annual average concentration from one or a number of years of data is the design value. When short term standards are most restrictive, it may be necessary to consider a broader range of concentrations than the highest value. For example, for pollutants such as SO₂, the highest, second-highest concentration is the design value. For pollutants with statistically based NAAQS, the design value is found by determining the more restrictive of: (1) The short-term concentration over the period specified in the standard, or (2) the long-term concentration that is not expected

to exceed the long-term NAAQS. Determination of design values for PM-10 is presented in more detail in EPA guidance.³⁴

10.2.3.2 NAAQS Analyses for New or Modified Sources

a. For new or modified sources predicted to have a significant ambient impact³⁵ and to be located in areas designated attainment or unclassifiable for the SO₂, Pb, NO₂, or CO NAAQS, the demonstration as to whether the source will cause or contribute to an air quality violation should be based on: (1) The highest estimated annual average concentration determined from annual averages of individual years; or (2) the highest, second-highest estimated concentration for averaging times of 24-hours or less; and (3) the significance of the spatial and temporal contribution to any modeled violation. For Pb, the highest estimated concentration based on an individual calendar quarter averaging period should be used. Background concentrations should be added to the estimated impact of the source. The most restrictive standard should be used in all cases to assess the threat of an air quality violation. For new or modified sources predicted to have a significant ambient impact³⁵ in areas designated attainment or unclassifiable for the PM-10 NAAQS, the demonstration of whether or not the source will cause or contribute to an air quality violation should be based on sufficient data to show whether: (1) The projected 24-hour average concentrations will exceed the 24-hour NAAQS more than once per year, on average; (2) the expected (i.e., average) annual mean concentration will exceed the annual NAAQS; and (3) the source contributes significantly, in a temporal and spatial sense, to any modeled violation.

10.2.3.3 PSD Air Quality Increments and Impacts

a. The allowable PSD increments for criteria pollutants are established by regulation and cited in 40 CFR 51.166. These maximum allowable increases in pollutant concentrations may be exceeded once per year at each site, except for the annual increment that may not be exceeded. The highest, second-highest increase in estimated concentrations for the short term averages as determined by a model should be less than or equal to the permitted increment. The modeled annual averages should not exceed the increment.

b. Screening techniques defined in subsection 4.2.1 can sometimes be used to estimate short term incremental concentrations for the first new source that triggers the baseline in a given area. However, when multiple increment-consuming sources are involved in the calculation, the use of a refined model with at least 1 year of site specific or

5 years of (off-site) NWS data is normally required (subsection 8.3.1.2). In such cases, sequential modeling must demonstrate that the allowable increments are not exceeded temporally and spatially, i.e., for all receptors for each time period throughout the year(s) (time period means the appropriate PSD averaging time, e.g., 3-hour, 24-hour, etc.).

c. The PSD regulations require an estimation of the SO₂, particulate matter (PM-10), and NO₂ impact on any Class I area. Normally, steady-state Gaussian plume models should not be applied at distances greater than can be accommodated by the steady state assumptions inherent in such models. The maximum distance for refined steady-state Gaussian plume model application for regulatory purposes is generally considered to be 50km. Beyond the 50km range, screening techniques may be used to determine if more refined modeling is needed. If refined models are needed, long range transport models should be considered in accordance with subsection 6.2.3. As previously noted in Sections 3 and 7, the need to involve the Federal Land Manager in decisions on potential air quality impacts, particularly in relation to PSD Class I areas, cannot be overemphasized.

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APPENDIX A TO APPENDIX W OF PART 51—SUMMARIES OF PREFERRED AIR QUALITY MODELS

TABLE OF CONTENTS

- A.0 Introduction and Availability
- A.1 AERMOD
- A.2 Buoyant Line and Point Source Dispersion Model (BLP)
- A.3 CALINE3
- A.4 CALPUFF
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- A.6 Offshore and Coastal Dispersion Model (OCD)
- A.REF References

A.0 INTRODUCTION AND AVAILABILITY

(1) This appendix summarizes key features of refined air quality models preferred for specific regulatory applications. For each model, information is provided on availability, approximate cost (where applicable), regulatory use, data input, output format

and options, simulation of atmospheric physics, and accuracy. These models may be used without a formal demonstration of applicability provided they satisfy the recommendations for regulatory use; not all options in the models are necessarily recommended for regulatory use.

(2) Many of these models have been subjected to a performance evaluation using comparisons with observed air quality data. Where possible, several of the models contained herein have been subjected to evaluation exercises, including (1) statistical performance tests recommended by the American Meteorological Society and (2) peer scientific reviews. The models in this appendix have been selected on the basis of the results of the model evaluations, experience with previous use, familiarity of the model to various air quality programs, and the costs and resource requirements for use.

(3) Codes and documentation for all models listed in this appendix are available from EPA's Support Center for Regulatory Air Models (SCRAM) Web site at <http://www.epa.gov/scram001>. Documentation is also available from the National Technical Information Service (NTIS), <http://www.ntis.gov> or U.S. Department of Commerce, Springfield, VA 22161; phone: (800) 553-6847. Where possible, accession numbers are provided.

A.1 AMS/EPA REGULATORY MODEL—AERMOD

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Availability

The model codes and associated documentation are available on EPA's Internet SCRAM Web site (Section A.0).

Abstract

AERMOD is a steady-state plume dispersion model for assessment of pollutant concentrations from a variety of sources. AERMOD simulates transport and dispersion from multiple point, area, or volume sources based on an up-to-date characterization of the atmospheric boundary layer. Sources may be located in rural or urban areas, and receptors may be located in simple or complex terrain. AERMOD accounts for building wake effects (i.e., plume downwash) based on the PRIME building downwash algorithms. The model employs hourly sequential preprocessed meteorological data to estimate concentrations for averaging times from one hour to one year (also multiple years). AERMOD is designed to operate in concert with two pre-processor codes: AERMET processes meteorological data for input to AERMOD, and AERMAP processes terrain elevation data and generates receptor information for input to AERMOD.

a. Recommendations for Regulatory Use

(1) AERMOD is appropriate for the following applications:

- Point, volume, and area sources;
- Surface, near-surface, and elevated releases;
- Rural or urban areas;
- Simple and complex terrain;
- Transport distances over which steady-state assumptions are appropriate, up to 50km;
- 1-hour to annual averaging times; and
- Continuous toxic air emissions.

(2) For regulatory applications of AERMOD, the regulatory default option should be set, i.e., the parameter DFAULT should be employed in the MODELOPT record in the Control Pathway. The DFAULT option requires the use of terrain elevation data, stack-tip downwash, sequential date checking, and does not permit the use of the model in the SCREEN mode. In the regulatory default mode, pollutant half life or decay options are not employed, ex-

cept in the case of an urban source of sulfur dioxide where a four-hour half life is applied. Terrain elevation data from the U.S. Geological Survey 7.5-Minute Digital Elevation Model (edcwww.cr.usgs.gov/doc/edchome/ndcddb/ndcddb.html) or equivalent (approx. 30-meter resolution) should be used in all applications. In some cases, exceptions of the terrain data requirement may be made in consultation with the permit/SIP reviewing authority.

b. Input Requirements

(1) Source data: Required input includes source type, location, emission rate, stack height, stack inside diameter, stack gas exit velocity, stack gas temperature, area and volume source dimensions, and source elevation. Building dimensions and variable emission rates are optional.

(2) Meteorological data: The AERMET meteorological preprocessor requires input of surface characteristics, including surface roughness (zo), Bowen ratio, and albedo, as well as, hourly observations of wind speed between 7zo and 100m (reference wind speed measurement from which a vertical profile can be developed), wind direction, cloud cover, and temperature between zo and 100m (reference temperature measurement from which a vertical profile can be developed). Surface characteristics may be varied by wind sector and by season or month. A morning sounding (in National Weather Service format) from a representative upper air station, latitude, longitude, time zone, and wind speed threshold are also required in AERMET (instrument threshold is only required for site specific data). Additionally, measured profiles of wind, temperature, vertical and lateral turbulence may be required in certain applications (e.g., in complex terrain) to adequately represent the meteorology affecting plume transport and dispersion. Optionally, measurements of solar, or net radiation may be input to AERMET. Two files are produced by the AERMET meteorological preprocessor for input to the AERMOD dispersion model. The surface file contains observed and calculated surface variables, one record per hour. The profile file contains the observations made at each level of a meteorological tower (or remote sensor), or the one-level observations taken from other representative data (e.g., National Weather Service surface observations), one record per level per hour.

(i) Data used as input to AERMET should possess an adequate degree of representativeness to insure that the wind, temperature and turbulence profiles derived by AERMOD are both laterally and vertically representative of the source area. The adequacy of input data should be judged independently for each variable. The values for surface roughness, Bowen ratio, and albedo should

reflect the surface characteristics in the vicinity of the meteorological tower, and should be adequately representative of the modeling domain. Finally, the primary atmospheric input variables including wind speed and direction, ambient temperature, cloud cover, and a morning upper air sounding should also be adequately representative of the source area.

(ii) For recommendations regarding the length of meteorological record needed to perform a regulatory analysis with AERMOD, see Section 8.3.1.

(3) Receptor data: Receptor coordinates, elevations, height above ground, and hill height scales are produced by the AERMAP terrain preprocessor for input to AERMOD. Discrete receptors and/or multiple receptor grids, Cartesian and/or polar, may be employed in AERMOD. AERMAP requires input of Digital Elevation Model (DEM) terrain data produced by the U.S. Geological Survey (USGS), or other equivalent data. AERMAP can be used optionally to estimate source elevations.

c. Output

Printed output options include input information, high concentration summary tables by receptor for user-specified averaging periods, maximum concentration summary tables, and concurrent values summarized by receptor for each day processed. Optional output files can be generated for: a listing of occurrences of exceedances of user-specified threshold value; a listing of concurrent (raw) results at each receptor for each hour modeled, suitable for post-processing; a listing of design values that can be imported into graphics software for plotting contours; an unformatted listing of raw results above a threshold value with a special structure for use with the TOXX model component of TOXST; a listing of concentrations by rank (e.g., for use in quantile-quantile plots); and, a listing of concentrations, including arc-maximum normalized concentrations, suitable for model evaluation studies.

d. Type of Model

AERMOD is a steady-state plume model, using Gaussian distributions in the vertical and horizontal for stable conditions, and in the horizontal for convective conditions. The vertical concentration distribution for convective conditions results from an assumed bi-Gaussian probability density function of the vertical velocity.

e. Pollutant Types

AERMOD is applicable to primary pollutants and continuous releases of toxic and hazardous waste pollutants. Chemical transformation is treated by simple exponential decay.

f. Source-Receptor Relationships

AERMOD applies user-specified locations for sources and receptors. Actual separation between each source-receptor pair is used. Source and receptor elevations are user input or are determined by AERMAP using USGS DEM terrain data. Receptors may be located at user-specified heights above ground level.

g. Plume Behavior

(1) In the convective boundary layer (CBL), the transport and dispersion of a plume is characterized as the superposition of three modeled plumes: The direct plume (from the stack), the indirect plume, and the penetrated plume, where the indirect plume accounts for the lofting of a buoyant plume near the top of the boundary layer, and the penetrated plume accounts for the portion of a plume that, due to its buoyancy, penetrates above the mixed layer, but can disperse downward and re-enter the mixed layer. In the CBL, plume rise is superposed on the displacements by random convective velocities (Weil *et al.*, 1997).

(2) In the stable boundary layer, plume rise is estimated using an iterative approach, similar to that in the CTDMPPLUS model (see A.5 in this appendix).

(3) Stack-tip downwash and buoyancy induced dispersion effects are modeled. Building wake effects are simulated for stacks less than good engineering practice height using the methods contained in the PRIME downwash algorithms (Schulman, *et al.*, 2000). For plume rise affected by the presence of a building, the PRIME downwash algorithm uses a numerical solution of the mass, energy and momentum conservation laws (Zhang and Ghoniem, 1993). Streamline deflection and the position of the stack relative to the building affect plume trajectory and dispersion. Enhanced dispersion is based on the approach of Weil (1996). Plume mass captured by the cavity is well-mixed within the cavity. The captured plume mass is re-emitted to the far wake as a volume source.

(4) For elevated terrain, AERMOD incorporates the concept of the critical dividing streamline height, in which flow below this height remains horizontal, and flow above this height tends to rise up and over terrain (Snyder *et al.*, 1985). Plume concentration estimates are the weighted sum of these two limiting plume states. However, consistent with the steady-state assumption of uniform horizontal wind direction over the modeling domain, straight-line plume trajectories are assumed, with adjustment in the plume/receptor geometry used to account for the terrain effects.

h. Horizontal Winds

Vertical profiles of wind are calculated for each hour based on measurements and surface-layer similarity (scaling) relationships. At a given height above ground, for a given hour, winds are assumed constant over the modeling domain. The effect of the vertical variation in horizontal wind speed on dispersion is accounted for through simple averaging over the plume depth.

i. Vertical Wind Speed

In convective conditions, the effects of random vertical updraft and downdraft velocities are simulated with a bi-Gaussian probability density function. In both convective and stable conditions, the mean vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

Gaussian horizontal dispersion coefficients are estimated as continuous functions of the parameterized (or measured) ambient lateral turbulence and also account for buoyancy-induced and building wake-induced turbulence. Vertical profiles of lateral turbulence are developed from measurements and similarity (scaling) relationships. Effective turbulence values are determined from the portion of the vertical profile of lateral turbulence between the plume height and the receptor height. The effective lateral turbulence is then used to estimate horizontal dispersion.

k. Vertical Dispersion

In the stable boundary layer, Gaussian vertical dispersion coefficients are estimated as continuous functions of parameterized vertical turbulence. In the convective boundary layer, vertical dispersion is characterized by a bi-Gaussian probability density function, and is also estimated as a continuous function of parameterized vertical turbulence. Vertical turbulence profiles are developed from measurements and similarity (scaling) relationships. These turbulence profiles account for both convective and mechanical turbulence. Effective turbulence values are determined from the portion of the vertical profile of vertical turbulence between the plume height and the receptor height. The effective vertical turbulence is then used to estimate vertical dispersion.

l. Chemical Transformation

Chemical transformations are generally not treated by AERMOD. However, AERMOD does contain an option to treat chemical transformation using simple exponential decay, although this option is typically not used in regulatory applications, except for sources of sulfur dioxide in urban areas. Either a decay coefficient or a half life is input by the user. Note also that the Plume Volume Molar Ratio Method (subsection 5.1) and

the Ozone Limiting Method (subsection 5.2.4) and for point-source NO₂ analyses are available as non-regulatory options.

m. Physical Removal

AERMOD can be used to treat dry and wet deposition for both gases and particles.

n. Evaluation Studies

American Petroleum Institute, 1998. Evaluation of State of the Science of Air Quality Dispersion Model, Scientific Evaluation, prepared by Woodward-Clyde Consultants, Lexington, Massachusetts, for American Petroleum Institute, Washington, D.C., 20005-4070.

Brode, R.W., 2002. Implementation and Evaluation of PRIME in AERMOD. Preprints of the 12th Joint Conference on Applications of Air Pollution Meteorology, May 20-24, 2002; American Meteorological Society, Boston, MA.

Brode, R.W., 2004. Implementation and Evaluation of Bulk Richardson Number Scheme in AERMOD. 13th Joint Conference on Applications of Air Pollution Meteorology, August 23-26, 2004; American Meteorological Society, Boston, MA.

Environmental Protection Agency, 2003. AERMOD: Latest Features and Evaluation Results. Publication No. EPA-454/R-03-003. U.S. Environmental Protection Agency, Research Triangle Park, NC. Available at <http://www.epa.gov/scram001/>.

A.2 BUOYANT LINE AND POINT SOURCE DISPERSION MODEL (BLP)

Reference

Schulman, Lloyd L., and Joseph S. Scire, 1980. Buoyant Line and Point Source (BLP) Dispersion Model User's Guide. Document P-7304B. Environmental Research and Technology, Inc., Concord, MA. (NTIS No. PB 81-164642; also available at <http://www.epa.gov/scram001/>)

Availability

The computer code is available on EPA's Internet SCRAM Web site and also on diskette (as PB 2002-500051) from the National Technical Information Service (see Section A.0).

Abstract

BLP is a Gaussian plume dispersion model designed to handle unique modeling problems associated with aluminum reduction plants, and other industrial sources where plume rise and downwash effects from stationary line sources are important.

a. Recommendations for Regulatory Use

(1) The BLP model is appropriate for the following applications:

- Aluminum reduction plants which contain buoyant, elevated line sources;

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- Rural areas;
- Transport distances less than 50 kilometers;
- Simple terrain; and
- One hour to one year averaging times.

(2) The following options should be selected for regulatory applications:

- (i) Rural (IRU=1) mixing height option;
- (ii) Default (no selection) for plume rise wind shear (LSHEAR), transitional point source plume rise (LTRANS), vertical potential temperature gradient (DTHTA), vertical wind speed power law profile exponents (PEXP), maximum variation in number of stability classes per hour (IDELS), pollutant decay (DECFAC), the constant in Briggs' stable plume rise equation (CONST2), constant in Briggs' neutral plume rise equation (CONST3), convergence criterion for the line source calculations (CRIT), and maximum iterations allowed for line source calculations (MAXIT); and
- (iii) Terrain option (TERAN) set equal to 0.0, 0.0, 0.0, 0.0, 0.0, 0.0

(3) For other applications, BLP can be used if it can be demonstrated to give the same estimates as a recommended model for the same application, and will subsequently be executed in that mode.

(4) BLP can be used on a case-by-case basis with specific options not available in a recommended model if it can be demonstrated, using the criteria in Section 3.2, that the model is more appropriate for a specific application.

b. Input Requirements

(1) Source data: point sources require stack location, elevation of stack base, physical stack height, stack inside diameter, stack gas exit velocity, stack gas exit temperature, and pollutant emission rate. Line sources require coordinates of the end points of the line, release height, emission rate, average line source width, average building width, average spacing between buildings, and average line source buoyancy parameter.

(2) Meteorological data: surface weather data from a preprocessor such as PCRAMMET which provides hourly stability class, wind direction, wind speed, temperature, and mixing height.

(3) Receptor data: locations and elevations of receptors, or location and size of receptor grid or request automatically generated receptor grid.

c. Output

(1) Printed output (from a separate post-processor program) includes:

(2) Total concentration or, optionally, source contribution analysis; monthly and annual frequency distributions for 1-, 3-, and 24-hour average concentrations; tables of 1-, 3-, and 24-hour average concentrations at each receptor; table of the annual (or length

of run) average concentrations at each receptor;

(3) Five highest 1-, 3-, and 24-hour average concentrations at each receptor; and

(4) Fifty highest 1-, 3-, and 24-hour concentrations over the receptor field.

d. Type of Model

BLP is a gaussian plume model.

e. Pollutant Types

BLP may be used to model primary pollutants. This model does not treat settling and deposition.

f. Source-Receptor Relationship

(1) BLP treats up to 50 point sources, 10 parallel line sources, and 100 receptors arbitrarily located.

(2) User-input topographic elevation is applied for each stack and each receptor.

g. Plume Behavior

(1) BLP uses plume rise formulas of Schulman and Scire (1980).

(2) Vertical potential temperature gradients of 0.02 Kelvin per meter for E stability and 0.035 Kelvin per meter are used for stable plume rise calculations. An option for user input values is included.

(3) Transitional rise is used for line sources.

(4) Option to suppress the use of transitional plume rise for point sources is included.

(5) The building downwash algorithm of Schulman and Scire (1980) is used.

h. Horizontal Winds

(1) Constant, uniform (steady-state) wind is assumed for an hour.

Straight line plume transport is assumed to all downwind distances.

(2) Wind speeds profile exponents of 0.10, 0.15, 0.20, 0.25, 0.30, and 0.30 are used for stability classes A through F, respectively. An option for user-defined values and an option to suppress the use of the wind speed profile feature are included.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

(1) Rural dispersion coefficients are from Turner (1969), with no adjustment made for variations in surface roughness or averaging time.

(2) Six stability classes are used.

k. Vertical Dispersion

(1) Rural dispersion coefficients are from Turner (1969), with no adjustment made for variations in surface roughness.

(2) Six stability classes are used.

(3) Mixing height is accounted for with multiple reflections until the vertical plume standard deviation equals 1.6 times the mixing height; uniform mixing is assumed beyond that point.

(4) Perfect reflection at the ground is assumed.

l. Chemical Transformation

Chemical transformations are treated using linear decay. Decay rate is input by the user.

m. Physical Removal

Physical removal is not explicitly treated.

n. Evaluation Studies

Schulman, L.L. and J.S. Scire, 1980. Buoyant Line and Point Source (BLP) Dispersion Model User's Guide, P-7304B. Environmental Research and Technology, Inc., Concord, MA.

Scire, J.S. and L.L. Schulman, 1981. Evaluation of the BLP and ISC Models with SF₆ Tracer Data and SO₂ Measurements at Aluminum Reduction Plants. APCA Specialty Conference on Dispersion Modeling for Complex Sources, St. Louis, MO.

A.3 CALINE3

Reference

Benson, Paul E., 1979. CALINE3—A Versatile Dispersion Model for Predicting Air Pollutant Levels Near Highways and Arterial Streets. Interim Report, Report Number FHWA/CA/TL-79/23. Federal Highway Administration, Washington, DC (NTIS No. PB 80-220841).

Availability

The CALINE3 model is available on diskette (as PB 95-502712) from NTIS. The source code and user's guide are also available on EPA's Internet SCRAM Web site (Section A.0).

Abstract

CALINE3 can be used to estimate the concentrations of nonreactive pollutants from highway traffic. This steady-state Gaussian model can be applied to determine air pollution concentrations at receptor locations downwind of "at-grade," "fill," "bridge," and "cut section" highways located in relatively uncomplicated terrain. The model is applicable for any wind direction, highway orientation, and receptor location. The model has adjustments for averaging time and surface roughness, and can handle up to 20 links and 20 receptors. It also contains an algorithm for deposition and settling velocity so that particulate concentrations can be predicted.

a. Recommendations for Regulatory Use

CALINE-3 is appropriate for the following applications:

- Highway (line) sources;
- Urban or rural areas;
- Simple terrain;
- Transport distances less than 50 kilometers; and
- One-hour to 24-hour averaging times.

b. Input Requirements

(1) Source data: up to 20 highway links classed as "at-grade," "fill," "bridge," or "depressed"; coordinates of link end points; traffic volume; emission factor; source height; and mixing zone width.

(2) Meteorological data: wind speed, wind angle (measured in degrees clockwise from the Y axis), stability class, mixing height, ambient (background to the highway) concentration of pollutant.

(3) Receptor data: coordinates and height above ground for each receptor.

c. Output

Printed output includes concentration at each receptor for the specified meteorological condition.

d. Type of Model

CALINE-3 is a Gaussian plume model.

e. Pollutant Types

CALINE-3 may be used to model primary pollutants.

f. Source-Receptor Relationship

(1) Up to 20 highway links are treated.

(2) CALINE-3 applies user input location and emission rate for each link. User-input receptor locations are applied.

g. Plume Behavior

Plume rise is not treated.

h. Horizontal Winds

(1) User-input hourly wind speed and direction are applied.

(2) Constant, uniform (steady-state) wind is assumed for an hour.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

(1) Six stability classes are used.

(2) Rural dispersion coefficients from Turner (1969) are used, with adjustment for roughness length and averaging time.

(3) Initial traffic-induced dispersion is handled implicitly by plume size parameters.

k. Vertical Dispersion

- (1) Six stability classes are used.
- (2) Empirical dispersion coefficients from Benson (1979) are used including an adjustment for roughness length.
- (3) Initial traffic-induced dispersion is handled implicitly by plume size parameters.
- (4) Adjustment for averaging time is included.

l. Chemical Transformation

Not treated.

m. Physical Removal

Optional deposition calculations are included.

n. Evaluation Studies

Bemis, G.R. *et al.*, 1977. Air Pollution and Roadway Location, Design, and Operation—Project Overview. FHWA-CA-TL-7080-77-25, Federal Highway Administration, Washington, DC.

Cadle, S.H. *et al.*, 1976. Results of the General Motors Sulfate Dispersion Experiment, GMR-2107. General Motors Research Laboratories, Warren, MI.

Dabberdt, W.F., 1975. Studies of Air Quality on and Near Highways, Project 2761. Stanford Research Institute, Menlo Park, CA.

Environmental Protection Agency, 1986. Evaluation of Mobile Source Air Quality Simulation Models. EPA Publication No. EPA-450/4-86-002. Office of Air Quality Planning & Standards, Research Triangle Park, NC. (NTIS No. PB 86-167293)

A.4 CALPUFF

References

Scire, J.S., D.G. Strimaitis and R.J. Yamartino, 2000. A User's Guide for the CALPUFF Dispersion Model (Version 5.0). Earth Tech, Inc., Concord, MA.

Scire J.S., F.R. Robe, M.E. Fernau and R.J. Yamartino, 2000. A User's Guide for the CALMET Meteorological Model (Version 5.0). Earth Tech, Inc., Concord, MA.

Availability

The model code and its documentation are available at no cost for download from the model developers' Internet Web site: <http://www.src.com/calpuff/calpuff1.htm>. You may also contact Joseph Scire, Earth Tech, Inc., 196 Baker Avenue, Concord, MA 01742; Telephone: (978) 371-4270; Fax: (978) 371-2468; e-mail: JScire@alum.mit.edu.

Abstract

CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion modeling system that simulates the effects of time- and space-varying meteorological conditions

on pollutant transport, transformation, and removal. CALPUFF is intended for use on scales from tens of meters from a source to hundreds of kilometers. It includes algorithms for near-field effects such as stack tip downwash, building downwash, transitional buoyant and momentum plume rise, rain cap effects, partial plume penetration, subgrid scale terrain and coastal interactions effects, and terrain impingement as well as longer range effects such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, vertical wind shear effects, overwater transport, plume fumigation, and visibility effects of particulate matter concentrations.

a. Recommendations for Regulatory Use

(1) CALPUFF is appropriate for long range transport (source-receptor distances of 50 to several hundred kilometers) of emissions from point, volume, area, and line sources. The meteorological input data should be fully characterized with time-and-space-varying three dimensional wind and meteorological conditions using CALMET, as discussed in paragraphs 8.3(d) and 8.3.1.2(d) of Appendix W.

(2) CALPUFF may also be used on a case-by-case basis if it can be demonstrated using the criteria in Section 3.2 that the model is more appropriate for the specific application. The purpose of choosing a modeling system like CALPUFF is to fully treat stagnation, wind reversals, and time and space variations of meteorological conditions on transport and dispersion, as discussed in paragraph 7.2.8(a).

(3) For regulatory applications of CALMET and CALPUFF, the regulatory default option should be used. Inevitably, some of the model control options will have to be set specific for the application using expert judgment and in consultation with the appropriate reviewing authorities.

b. Input Requirements

Source Data:

1. Point sources: Source location, stack height, diameter, exit velocity, exit temperature, base elevation, wind direction specific building dimensions (for building downwash calculations), and emission rates for each pollutant. Particle size distributions may be entered for particulate matter. Temporal emission factors (diurnal cycle, monthly cycle, hour/season, wind speed/stability class, or temperature-dependent emission factors) may also be entered. Arbitrarily-varying point source parameters may be entered from an external file.

2. Area sources: Source location and shape, release height, base elevation, initial vertical distribution (σ_z) and emission rates for each pollutant. Particle size distributions

may be entered for particulate matter. Temporal emission factors (diurnal cycle, monthly cycle, hour/season, wind speed/stability class, or temperature-dependent emission factors) may also be entered. Arbitrarily-varying area source parameters may be entered from an external file. Area sources specified in the external file are allowed to be buoyant and their location, size, shape, and other source characteristics are allowed to change in time.

3. Volume sources: Source location, release height, base elevation, initial horizontal and vertical distributions (σ_y , σ_z) and emission rates for each pollutant. Particle size distributions may be entered for particulate matter. Temporal emission factors (diurnal cycle, monthly cycle, hour/season, wind speed/stability class, or temperature-dependent emission factors) may also be entered. Arbitrarily-varying volume source parameters may be entered from an external file. Volume sources with buoyancy can be simulated by treating the source as a point source and entering initial plume size parameters—initial (σ_y , σ_z)—to define the initial size of the volume source.

4. Line sources: Source location, release height, base elevation, average buoyancy parameter, and emission rates for each pollutant. Building data may be entered for line source emissions experiencing building downwash effects. Particle size distributions may be entered for particulate matter. Temporal emission factors (diurnal cycle, monthly cycle, hour/season, wind speed/stability class, or temperature-dependent emission factors) may also be entered. Arbitrarily-varying line source parameters may be entered from an external file.

Meteorological Data (different forms of meteorological input can be used by CALPUFF):

1. Time-dependent three-dimensional (3-D) meteorological fields generated by CALMET. This is the preferred mode for running CALPUFF. Data inputs used by CALMET include surface observations of wind speed, wind direction, temperature, cloud cover, ceiling height, relative humidity, surface pressure, and precipitation (type and amount), and upper air sounding data (wind speed, wind direction, temperature, and height) and air-sea temperature differences (over water). Optional 3-D meteorological prognostic model output (e.g., from models such as MM5, RUC, Eta and RAMS) can be used by CALMET as well (paragraph 8.3.1.2(d)). CALMET contains an option to be run in “No-observations” mode (Robe et al., 2002), which allows the 3-D CALMET meteorological fields to be based on prognostic model output alone, without observations. This allows CALMET and CALPUFF to be run in prognostic mode for forecast applications.

2. Single station surface and upper air meteorological data in CTDMPPLUS data file formats (SURFACE.DAT and PROFILE.DAT files) or AERMOD data file formats. These options allow a vertical variation in the meteorological parameters but no horizontal spatial variability.

3. Single station meteorological data in ISCST3 data file format. This option does not account for variability of the meteorological parameters in the horizontal or vertical, except as provided for by the use of stability-dependent wind shear exponents and average temperature lapse rates.

Gridded terrain and land use data are required as input into CALMET when Option 1 is used. Geophysical processor programs are provided that interface the modeling system to standard terrain and land use data bases available from various sources such as the U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA).

Receptor Data:

CALPUFF includes options for gridded and non-gridded (discrete) receptors. Special subgrid-scale receptors are used with the subgrid-scale complex terrain option. An option is provided for discrete receptors to be placed at ground-level or above the local ground level (i.e., flagpole receptors). Gridded and subgrid-scale receptors are placed at the local ground level only.

Other Input:

CALPUFF accepts hourly observations of ozone concentrations for use in its chemical transformation algorithm. Monthly concentrations of ammonia concentrations can be specified in the CALPUFF input file, although higher time-resolution ammonia variability can be computed using the POSTUTIL program. Subgrid-scale coastlines can be specified in its coastal boundary file. Optional, user-specified deposition velocities and chemical transformation rates can also be entered. CALPUFF accepts the CTDMPPLUS terrain and receptor files for use in its subgrid-scale terrain algorithm. Inflow boundary conditions of modeled pollutants can be specified in a boundary condition file. Liquid water content variables including cloud water/ice and precipitation water/ice can be used as input for visibility analyses and other CALPUFF modules.

c. Output

CALPUFF produces files of hourly concentrations of ambient concentrations for each modeled species, wet deposition fluxes, dry deposition fluxes, and for visibility applications, extinction coefficients. Postprocessing programs (PRTMET, CALPOST, CALSUM, APPEND, and POSTUTIL) provide options for summing, scaling, analyzing and displaying the modeling results. CALPOST contains options for computing of light extinction (visibility) and

POSTUTIL allows the re-partitioning of nitric acid and nitrate to account for the effects of ammonia limitation (Scire *et al.*, 2001; Escoffier-Czaja and Scire, 2002). CALPUFF contains an options to output liquid water concentrations for use in computing visible plume lengths and frequency of icing and fogging from cooling towers and other water vapor sources. The CALPRO Graphical User Interface (GUI) contains options for creating graphics such as contour plots, vector plots and other displays when linked to graphics software.

d. Type of Model

(1) CALPUFF is a non-steady-state time- and space-dependent Gaussian puff model. CALPUFF treats primary pollutants and simulates secondary pollutant formation using a parameterized, quasi-linear chemical conversion mechanism. Pollutants treated include SO_2 , $\text{SO}_4^{=}$, NO_x (i.e., $\text{NO} + \text{NO}_2$), HNO_3 , NO_3^- , NH_3 , PM-10, PM-2.5, toxic pollutants and others pollutant species that are either inert or subject to quasi-linear chemical reactions. The model includes a resistance-based dry deposition model for both gaseous pollutants and particulate matter. Wet deposition is treated using a scavenging coefficient approach. The model has detailed parameterizations of complex terrain effects, including terrain impingement, side-wall scrapping, and steep-walled terrain influences on lateral plume growth. A subgrid-scale complex terrain module based on a dividing streamline concept divides the flow into a lift component traveling over the obstacle and a wrap component deflected around the obstacle.

(2) The meteorological fields used by CALPUFF are produced by the CALMET meteorological model. CALMET includes a diagnostic wind field model containing parameterized treatments of slope flows, valley flows, terrain blocking effects, and kinematic terrain effects, lake and sea breeze circulations, a divergence minimization procedure, and objective analysis of observational data. An energy-balance scheme is used to compute sensible and latent heat fluxes and turbulence parameters over land surfaces. A profile method is used over water. CALMET contains interfaces to prognostic meteorological models such as the Penn State/NCAR Mesoscale Model (e.g., MM5; Section 12.0, ref. 86), as well as the RAMS, Ruc and Eta models.

e. Pollutant Types

CALPUFF may be used to model gaseous pollutants or particulate matter that are inert or which undergo quasi-linear chemical reactions, such as SO_2 , $\text{SO}_4^{=}$, NO_x (i.e., $\text{NO} + \text{NO}_2$), HNO_3 , NO_3^- , NH_3 , PM-10, PM-2.5 and toxic pollutants. For regional haze analyses,

sulfate and nitrate particulate components are explicitly treated.

f. Source-Receptor Relationships

CALPUFF contains no fundamental limitations on the number of sources or receptors. Parameter files are provided that allow the user to specify the maximum number of sources, receptors, puffs, species, grid cells, vertical layers, and other model parameters. Its algorithms are designed to be suitable for source-receptor distances from tens of meters to hundreds of kilometers.

g. Plume Behavior

Momentum and buoyant plume rise is treated according to the plume rise equations of Briggs (1975) for non-downwashing point sources, Schulman and Scire (1980) for line sources and point sources subject to building downwash effects using the Schulman-Scire downwash algorithm, and Zhang (1993) for buoyant area sources and point sources affected by building downwash when using the PRIME building downwash method. Stack tip downwash effects and partial plume penetration into elevated temperature inversions are included. An algorithm to treat horizontally-oriented vents and stacks with rain caps is included.

h. Horizontal Winds

A three-dimensional wind field is computed by the CALMET meteorological model. CALMET combines an objective analysis procedure using wind observations with parameterized treatments of slope flows, valley flows, terrain kinematic effects, terrain blocking effects, and sea/lake breeze circulations. CALPUFF may optionally use single station (horizontally-constant) wind fields in the CTDMPLUS, AERMOD or ISCST3 data formats.

i. Vertical Wind Speed

Vertical wind speeds are not used explicitly by CALPUFF. Vertical winds are used in the development of the horizontal wind components by CALMET.

j. Horizontal Dispersion

Turbulence-based dispersion coefficients provide estimates of horizontal plume dispersion based on measured or computed values of σ_v . The effects of building downwash and buoyancy-induced dispersion are included. The effects of vertical wind shear are included through the puff splitting algorithm. Options are provided to use Pasquill-Gifford (rural) and McElroy-Pooler (urban) dispersion coefficients. Initial plume size from area or volume sources is allowed.

k. Vertical Dispersion

Turbulence-based dispersion coefficients provide estimates of vertical plume dispersion based on measured or computed values of σ_w . The effects of building downwash and buoyancy-induced dispersion are included. Vertical dispersion during convective conditions is simulated with a probability density function (pdf) model based on Weil *et al.* (1997). Options are provided to use Pasquill-Gifford (rural) and McElroy-Pooler (urban) dispersion coefficients. Initial plume size from area or volume sources is allowed.

l. Chemical Transformation

Gas phase chemical transformations are treated using parameterized models of SO₂ conversion to SO₄= and NO conversion to NO₃-, HNO₃, and NO₂. Organic aerosol formation is treated. The POSTUTIL program contains an option to re-partition HNO₃ and NO₃- in order to treat the effects of ammonia limitation.

m. Physical Removal

Dry deposition of gaseous pollutants and particulate matter is parameterized in terms of a resistance-based deposition model. Gravitational settling, inertial impaction, and Brownian motion effects on deposition of particulate matter is included. CALPUFF contains an option to evaluate the effects of plume tilt resulting from gravitational settling. Wet deposition of gases and particulate matter is parameterized in terms of a scavenging coefficient approach.

n. Evaluation Studies

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Strimaitis, D.G., J.S. Scire and J.C. Chang, 1998. Evaluation of the CALPUFF Dispersion Model with Two Power Plant Data Sets. Tenth Joint Conference on the Application of Air Pollution Meteorology, Phoenix, Arizona. American Meteorological Society, Boston, MA. January 11-16, 1998.

A.5 COMPLEX TERRAIN DISPERSION MODEL PLUS ALGORITHMS FOR UNSTABLE SITUATIONS (CTDMPLUS)

Reference

Perry, S.G., D.J. Burns, L.H. Adams, R.J. Paine, M.G. Dennis, M.T. Mills, D.G. Strimaitis, R.J. Yamartino and E.M. Insley, 1989. User's Guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS). Volume 1: Model Descriptions and User Instructions. EPA Publication No. EPA-600/8-89-041. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 89-181424)

Perry, S.G., 1992. CTDMPLUS: A Dispersion Model for Sources near Complex Topography. Part I: Technical Formulations. *Journal of Applied Meteorology*, 31(7): 633-645.

Availability

This model code is available on EPA's Internet SCRAM Web site and also on diskette (as PB 90-504119) from the National Technical Information Service (Section A.0).

Abstract

CTDMPLUS is a refined point source Gaussian air quality model for use in all stability conditions for complex terrain applications. The model contains, in its entirety, the technology of CTDM for stable and neutral conditions. However, CTDMPLUS can also simulate daytime, unstable conditions, and has a number of additional capabilities for improved user friendliness. Its use of meteorological data and terrain information is

different from other EPA models; considerable detail for both types of input data is required and is supplied by preprocessors specifically designed for CTDMPPLUS. CTDMPPLUS requires the parameterization of individual hill shapes using the terrain preprocessor and the association of each model receptor with a particular hill.

a. Recommendation for Regulatory Use

CTDMPPLUS is appropriate for the following applications:

- Elevated point sources;
- Terrain elevations above stack top;
- Rural or urban areas;
- Transport distances less than 50 kilometers; and
- One hour to annual averaging times when used with a post-processor program such as CHAVG.

b. Input Requirements

(1) Source data: For each source, user supplies source location, height, stack diameter, stack exit velocity, stack exit temperature, and emission rate; if variable emissions are appropriate, the user supplies hourly values for emission rate, stack exit velocity, and stack exit temperature.

(2) Meteorological data: For applications of CTDMPPLUS, multiple level (typically three or more) measurements of wind speed and direction, temperature and turbulence (wind fluctuation statistics) are required to create the basic meteorological data file ("PROFILE"). Such measurements should be obtained up to the representative plume height(s) of interest (*i.e.*, the plume height(s) under those conditions important to the determination of the design concentration). The representative plume height(s) of interest should be determined using an appropriate complex terrain screening procedure (*e.g.*, CTSCREEN) and should be documented in the monitoring/modeling protocol. The necessary meteorological measurements should be obtained from an appropriately sited meteorological tower augmented by SODAR and/or RASS if the representative plume height(s) of interest is above the levels represented by the tower measurements. Meteorological preprocessors then create a SURFACE data file (hourly values of mixed layer heights, surface friction velocity, Monin-Obukhov length and surface roughness length) and a RAWINsonde data file (upper air measurements of pressure, temperature, wind direction, and wind speed).

(3) Receptor data: receptor names (up to 400) and coordinates, and hill number (each receptor must have a hill number assigned).

(4) Terrain data: user inputs digitized contour information to the terrain preprocessor which creates the TERRAIN data file (for up to 25 hills).

c. Output

(1) When CTDMPPLUS is run, it produces a concentration file, in either binary or text format (user's choice), and a list file containing a verification of model inputs, *i.e.*,

- Input meteorological data from "SURFACE" and "PROFILE".
- Stack data for each source.
- Terrain information.
- Receptor information.
- Source-receptor location (line printer map).

(2) In addition, if the case-study option is selected, the listing includes:

- Meteorological variables at plume height.
- Geometrical relationships between the source and the hill.
- Plume characteristics at each receptor, *i.e.*,

- Distance in along-flow and cross flow direction
- Effective plume-receptor height difference
- Effective σ_y & σ_z values, both flat terrain and hill induced (the difference shows the effect of the hill)
- Concentration components due to WRAP, LIFT and FLAT.

(3) If the user selects the TOPN option, a summary table of the top 4 concentrations at each receptor is given. If the ISOR option is selected, a source contribution table for every hour will be printed.

(4) A separate disk file of predicted (1-hour only) concentrations ("CONC") is written if the user chooses this option. Three forms of output are possible:

(i) A binary file of concentrations, one value for each receptor in the hourly sequence as run;

(ii) A text file of concentrations, one value for each receptor in the hourly sequence as run; or

(iii) A text file as described above, but with a listing of receptor information (names, positions, hill number) at the beginning of the file.

(3) Hourly information provided to these files besides the concentrations themselves includes the year, month, day, and hour information as well as the receptor number with the highest concentration.

d. Type of Model

CTDMPPLUS is a refined steady-state, point source plume model for use in all stability conditions for complex terrain applications.

e. Pollutant Types

CTDMPPLUS may be used to model non-reactive, primary pollutants.

f. Source-Receptor Relationship

Up to 40 point sources, 400 receptors and 25 hills may be used. Receptors and sources are

allowed at any location. Hill slopes are assumed not to exceed 15°, so that the linearized equation of motion for Boussinesq flow are applicable. Receptors upwind of the impingement point, or those associated with any of the hills in the modeling domain, require separate treatment.

g. Plume Behavior

(1) As in CTDm, the basic plume rise algorithms are based on Briggs' (1975) recommendations.

(2) A central feature of CTDmPLUS for neutral/stable conditions is its use of a critical dividing-streamline height (H_c) to separate the flow in the vicinity of a hill into two separate layers. The plume component in the upper layer has sufficient kinetic energy to pass over the top of the hill while streamlines in the lower portion are constrained to flow in a horizontal plane around the hill. Two separate components of CTDmPLUS compute ground-level concentrations resulting from plume material in each of these flows.

(3) The model calculates on an hourly (or appropriate steady averaging period) basis how the plume trajectory (and, in stable/neutral conditions, the shape) is deformed by each hill. Hourly profiles of wind and temperature measurements are used by CTDmPLUS to compute plume rise, plume penetration (a formulation is included to handle penetration into elevated stable layers, based on Briggs (1984)), convective scaling parameters, the value of H_c , and the Froude number above H_c .

h. Horizontal Winds

CTDmPLUS does not simulate calm meteorological conditions. Both scalar and vector wind speed observations can be read by the model. If vector wind speed is unavailable, it is calculated from the scalar wind speed. The assignment of wind speed (either vector or scalar) at plume height is done by either:

- Interpolating between observations above and below the plume height, or
- Extrapolating (within the surface layer) from the nearest measurement height to the plume height.

i. Vertical Wind Speed

Vertical flow is treated for the plume component above the critical dividing streamline height (H_c); see "Plume Behavior".

j. Horizontal Dispersion

Horizontal dispersion for stable/neutral conditions is related to the turbulence velocity scale for lateral fluctuations, σ_v , for which a minimum value of 0.2 m/s is used. Convective scaling formulations are used to estimate horizontal dispersion for unstable conditions.

k. Vertical Dispersion

Direct estimates of vertical dispersion for stable/neutral conditions are based on observed vertical turbulence intensity, *e.g.*, σ_w (standard deviation of the vertical velocity fluctuation). In simulating unstable (convective) conditions, CTDmPLUS relies on a skewed, bi-Gaussian probability density function (pdf) description of the vertical velocities to estimate the vertical distribution of pollutant concentration.

l. Chemical Transformation

Chemical transformation is not treated by CTDmPLUS.

m. Physical Removal

Physical removal is not treated by CTDmPLUS (complete reflection at the ground/hill surface is assumed).

n. Evaluation Studies

Burns, D.J., L.H. Adams and S.G. Perry, 1990. Testing and Evaluation of the CTDmPLUS Dispersion Model: Daytime Convective Conditions. Environmental Protection Agency, Research Triangle Park, NC.

Paumier, J.O., S.G. Perry and D.J. Burns, 1990. An Analysis of CTDmPLUS Model Predictions with the Lovett Power Plant Data Base. Environmental Protection Agency, Research Triangle Park, NC.

Paumier, J.O., S.G. Perry and D.J. Burns, 1992. CTDmPLUS: A Dispersion Model for Sources near Complex Topography. Part II: Performance Characteristics. *Journal of Applied Meteorology*, 31(7): 646-660.

A.6 OFFSHORE AND COASTAL DISPERSION MODEL (OCD)

Reference

DiCristofaro, D.C. and S.R. Hanna, 1989. OCD: The Offshore and Coastal Dispersion Model, Version 4. Volume I: User's Guide, and Volume II: Appendices. Sigma Research Corporation, Westford, MA. (NTIS Nos. PB 93-144384 and PB 93-144392; also available at <http://www.epa.gov/scram001/>)

Availability

This model code is available on EPA's Internet SCRAM Web site and also on diskette (as PB 91-505230) from the National Technical Information Service (see Section A.0). Official contact at Minerals Management Service: Mr. Dirk Herkhof, Parkway Atrium Building, 381 Elden Street, Herndon, VA 20170, Phone: (703) 787-1735.

Abstract

(1) OCD is a straight-line Gaussian model developed to determine the impact of offshore emissions from point, area or line sources on the air quality of coastal regions.

OCD incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. Hourly meteorological data are needed from both offshore and onshore locations. These include water surface temperature, overwater air temperature, mixing height, and relative humidity.

(2) Some of the key features include platform building downwash, partial plume penetration into elevated inversions, direct use of turbulence intensities for plume dispersion, interaction with the overland internal boundary layer, and continuous shoreline fumigation.

a. Recommendations for Regulatory Use

OCD has been recommended for use by the Minerals Management Service for emissions located on the Outer Continental Shelf (50 FR 12248; 28 March 1985). OCD is applicable for overwater sources where onshore receptors are below the lowest source height. Where onshore receptors are above the lowest source height, offshore plume transport and dispersion may be modeled on a case-by-case basis in consultation with the appropriate reviewing authority (paragraph 3.0(b)).

b. Input Requirements

(1) Source data: Point, area or line source location, pollutant emission rate, building height, stack height, stack gas temperature, stack inside diameter, stack gas exit velocity, stack angle from vertical, elevation of stack base above water surface and gridded specification of the land/water surfaces. As an option, emission rate, stack gas exit velocity and temperature can be varied hourly.

(2) Meteorological data (over water): Wind direction, wind speed, mixing height, relative humidity, air temperature, water surface temperature, vertical wind direction shear (optional), vertical temperature gradient (optional), turbulence intensities (optional).

(2) Meteorological data:

Over land: Surface weather data from a preprocessor such as PCRAMMET which provides hourly stability class, wind direction, wind speed, ambient temperature, and mixing height are required.

Over water: Hourly values for mixing height, relative humidity, air temperature, and water surface temperature are required; if wind speed/direction are missing, values over land will be used (if available); vertical wind direction shear, vertical temperature gradient, and turbulence intensities are optional.

(3) Receptor data: Location, height above local ground-level, ground-level elevation above the water surface.

c. Output

(1) All input options, specification of sources, receptors and land/water map including locations of sources and receptors.

(2) Summary tables of five highest concentrations at each receptor for each averaging period, and average concentration for entire run period at each receptor.

(3) Optional case study printout with hourly plume and receptor characteristics. Optional table of annual impact assessment from non-permanent activities.

(4) Concentration files written to disk or tape can be used by ANALYSIS postprocessor to produce the highest concentrations for each receptor, the cumulative frequency distributions for each receptor, the tabulation of all concentrations exceeding a given threshold, and the manipulation of hourly concentration files.

d. Type of Model

OCD is a Gaussian plume model constructed on the framework of the MPTEP model.

e. Pollutant Types

OCD may be used to model primary pollutants. Settling and deposition are not treated.

f. Source-Receptor Relationship

(1) Up to 250 point sources, 5 area sources, or 1 line source and 180 receptors may be used.

(2) Receptors and sources are allowed at any location.

(3) The coastal configuration is determined by a grid of up to 3600 rectangles. Each element of the grid is designated as either land or water to identify the coastline.

g. Plume Behavior

(1) As in ISC, the basic plume rise algorithms are based on Briggs' recommendations.

(2) Momentum rise includes consideration of the stack angle from the vertical.

(3) The effect of drilling platforms, ships, or any overwater obstructions near the source are used to decrease plume rise using a revised platform downwash algorithm based on laboratory experiments.

(4) Partial plume penetration of elevated inversions is included using the suggestions of Briggs (1975) and Weil and Brower (1984).

(5) Continuous shoreline fumigation is parameterized using the Turner method where complete vertical mixing through the thermal internal boundary layer (TIBL) occurs as soon as the plume intercepts the TIBL.

h. Horizontal Winds

(1) Constant, uniform wind is assumed for each hour.

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(2) Overwater wind speed can be estimated from overland wind speed using relationship of Hsu (1981).

(3) Wind speed profiles are estimated using similarity theory (Businger, 1973). Surface layer fluxes for these formulas are calculated from bulk aerodynamic methods.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

(1) Lateral turbulence intensity is recommended as a direct estimate of horizontal dispersion. If lateral turbulence intensity is not available, it is estimated from boundary layer theory. For wind speeds less than 8 m/s, lateral turbulence intensity is assumed inversely proportional to wind speed.

(2) Horizontal dispersion may be enhanced because of obstructions near the source. A virtual source technique is used to simulate the initial plume dilution due to downwash.

(3) Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement and wind direction shear enhancement.

(4) At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either lateral turbulence intensity or Pasquill-Gifford curves. The change is implemented where the plume intercepts the rising internal boundary layer.

k. Vertical Dispersion

(1) Observed vertical turbulence intensity is not recommended as a direct estimate of vertical dispersion. Turbulence intensity should be estimated from boundary layer theory as default in the model. For very stable conditions, vertical dispersion is also a function of lapse rate.

(2) Vertical dispersion may be enhanced because of obstructions near the source. A virtual source technique is used to simulate the initial plume dilution due to downwash.

(3) Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement.

(4) At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either vertical turbulence intensity or the Pasquill-Gifford coefficients. The change is implemented where the plume intercepts the rising internal boundary layer.

1. Chemical Transformation

Chemical transformations are treated using exponential decay. Different rates can be specified by month and by day or night.

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m. Physical Removal

Physical removal is also treated using exponential decay.

n. Evaluation Studies

DiCristofaro, D.C. and S.R. Hanna, 1989. OCD: The Offshore and Coastal Dispersion Model. Volume I: User's Guide. Sigma Research Corporation, Westford, MA.

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[70 FR 68228, Nov. 9, 2005]

APPENDIX X TO PART 51—EXAMPLES OF ECONOMIC INCENTIVE PROGRAMS

I. INTRODUCTION AND PURPOSE

This appendix contains examples of EIP's which are covered by the EIP rules. Program descriptions identify key provisions which distinguish the different model program types. The examples provide additional information and guidance on various types of regulatory programs collectively referred to as EIP's. The examples include programs involving stationary, area, and mobile sources. The definition section at 40 CFR 51.491 defines an EIP as a program which may include State established emission fees or a system of marketable permits, or a system of State fees on sale or manufacture of products the use of which contributes to O₃ formation, or any combination of the foregoing or other similar measures, as well as incentives and requirements to reduce vehicle emissions and vehicle miles traveled in the area, including any of the transportation control measures identified in section 108(f). Such programs span a wide spectrum of program designs.

The EIP's are comprised of several elements that, in combination with each other, must insure that the fundamental principles of any regulatory program (including accountability, enforceability and noninterference with other requirements of the Act)

are met. There are many possible combinations of program elements that would be acceptable. Also, it is important to emphasize that the effectiveness of an EIP is dependent upon the particular area in which it is implemented. No two areas face the same air quality circumstances and, therefore, effective strategies and programs will differ among areas.

Because of these considerations, the EPA is not specifying one particular design or type of strategy as acceptable for any given EIP. Such specific guidance would potentially discourage States (or other entities with delegated authority to administer parts of an implementation plan) from utilizing other equally viable program designs that may be more appropriate for their situation. Thus, the examples given in this Appendix are general in nature so as to avoid limiting innovation on the part of the States in developing programs tailored to individual State needs.

Another important consideration in designing effective EIP's is the extent to which different strategies, or programs targeted at different types of sources, can complement one another when implemented together as an EIP "package." The EPA encourages States to consider packaging different measures together when such a strategy is likely to increase the overall benefits from the program as a whole. Furthermore, some activities, such as information distribution or public awareness programs, while not EIP's in and of themselves, are often critical to the success of other measures and, therefore, would be appropriate complementary components of a program package. All SIP emissions reductions credits should reflect a consideration of the effectiveness of the entire package.

II. EXAMPLES OF STATIONARY AND MOBILE SOURCE ECONOMIC INCENTIVE STRATEGIES

There is a wide variety of programs that fall under the general heading of EIP's. Further, within each general type of program are several different basic program designs. This section describes common types of EIP's that have been implemented, designed, or discussed in the literature for stationary and mobile sources. The program types discussed below do not include all of the possible types of EIP's. Innovative approaches incorporating new ideas in existing programs, different combinations of existing program elements, or wholly new incentive systems provide additional opportunities for States to find ways to meet environmental goals at lower total cost.

A. Emissions Trading Markets

One prominent class of EIP's is based upon the creation of a market in which trading of source-specific emissions requirements may

occur. Such programs may include traditional rate-based emissions limits (generally referred to as emissions averaging) or overall limits on a source's total mass emissions per unit of time (generally referred to as an emissions cap). The emissions limits, which may be placed on individual emitting units or on facilities as a whole, may decline over time. The common feature of such programs is that sources have an ongoing incentive to reduce pollution and increased flexibility in meeting their regulatory requirements. A source may meet its own requirements either by directly preventing or controlling emissions or by trading or averaging with another source. Trading or averaging may occur within the same facility, within the same firm, or between different firms. Sources with lower cost abatement alternatives may provide the necessary emissions reductions to sources facing more expensive alternatives. These programs can lower the overall cost of meeting a given total level of abatement. All sources eligible to trade in an emissions market are faced with continuing incentives to find better ways of reducing emissions at the lowest possible cost, even if they are already meeting their own emissions requirements.

Stationary, area, and mobile sources could be allowed to participate in a common emissions trading market. Programs involving emissions trading markets are particularly effective at reducing overall costs when individual affected sources face significantly different emissions control costs. A wider range in control costs among affected sources creates greater opportunities for cost-reducing trades. Thus, for example, areas which face relatively high stationary source control costs relative to mobile source control costs benefit most by including both stationary and mobile sources in a single emissions trading market.

Programs involving emissions trading markets have generally been designated as either emission allowance or emission reduction credit (ERC) trading programs. The Federal Acid Rain Program is an example of an emission allowance trading program, while "bubbles" and "generic bubbles" created under the EPA's 1986 Emission Trading Policy Statement are examples of ERC trading. Allowance trading programs can establish emission allocations to be effective at the start of a program, at some specific time in the future, or at varying levels over time. An ERC trading program requires ERC's to be measured against a pre-established emission baseline. Allowance allocations or emission baselines can be established either directly by the EIP rules or by reference to traditional regulations (e.g., RACT requirements). In either type of program, sources can either meet their EIP requirements by maintaining their own emissions within the

limits established by the program, or by buying surplus allowances or ERC's from other sources. In any case, the State will need to establish adequate enforceable procedures for certifying and tracking trades, and for monitoring and enforcing compliance with the EIP.

The definition of the commodity to be traded and the design of the administrative procedures the buyer and seller must follow to complete a trade are obvious elements that must be carefully selected to help ensure a successful trading market that achieves the desired environmental goal at the lowest cost. An emissions market is defined as efficient if it achieves the environmental goal at the lowest possible total cost. Any feature of a program that unnecessarily increases the total cost without helping achieve the environmental goals causes market inefficiency. Thus, the design of an emission trading program should be evaluated not only in terms of the likelihood that the program design will ensure that the environmental goals of the program will be met, but also in terms of the costs that the design imposes upon market transactions and the impact of those costs on market efficiency.

Transaction costs are the investment in time and resources to acquire information about the price and availability of allowances or ERC's, to negotiate a trade, and to assure the trade is properly recorded and legally enforceable. All trading markets impose some level of transaction costs. The level of transaction costs in an emissions trading market are affected by various aspects of the design of the market, such as the nature of the procedures for reviewing, approving, and recording trades, the timing of such procedures (i.e., before or after the trade is made), uncertainties in the value of the allowance or credit being traded, the legitimacy of the allowance or credit being offered for sale, and the long-term integrity of the market itself. Emissions trading programs in which every transaction is different, such as programs requiring significant consideration of the differences in the chemical properties or geographic location of the emissions, can result in higher transaction costs than programs with a standardized trading commodity and well-defined rules for acceptable trades. Transaction costs are also affected by the relative ease with which information can be obtained about the availability and price of allowances or credits.

While the market considerations discussed above are clearly important in designing an efficient market to minimize the transaction costs of such a program, other considerations, such as regulatory certainty, enforcement issues, and public acceptance, also clearly need to be factored into the design of any emissions trading program.

B. Fee Programs

A fee on each unit of emissions is a strategy that can provide a direct incentive for sources to reduce emissions. Ideally, fees should be set so as to result in emissions being reduced to the socially optimal level considering the costs of control and the benefits of the emissions reductions. In order to motivate a change in emissions, the fees must be high enough that sources will actively seek to reduce emissions. It is important to note that not all emission fee programs are designed to motivate sources to lower emissions. Fee programs using small fees are designed primarily to generate revenue, often to cover some of the administrative costs of a regulatory program.

There can be significant variations in emission fee programs. For example, potential emissions could be targeted by placing a fee on an input (e.g., a fee on the quantity and BTU content of fuel used in an industrial boiler) rather than on actual emissions. Sources paying a fee on potential emissions could be eligible for a fee waiver or rebate by demonstrating that potential emissions are not actually emitted, such as through a carbon absorber system on a coating operation.

Some fee program variations are designed to mitigate the potentially large amount of revenue that a fee program could generate. Although more complex than a simple fee program, programs that reduce or eliminate the total revenues may be more readily adopted in a SIP than a simple emission fee. Some programs lower the amount of total revenues generated by waiving the fee on some emissions. These programs reduce the total amount of revenue generated, while providing an incentive to decrease emissions. Alternatively, a program may impose higher per-unit fees on a portion of the emissions stream, providing a more powerful but targeted incentive at the same revenue levels. For example, fees could be collected on all emissions in excess of some fixed level. The level could be set as a percentage of a baseline (e.g., fees on emissions above some percentage of historical emissions), or as the lowest emissions possible (e.g., fees on emissions in excess of the lowest demonstrated emissions from the source category).

Other fee programs are "revenue neutral," meaning that the pollution control agency does not receive any net revenues. One way to design a revenue-neutral program is to have both a fee provision and a rebate provision. Rebates must be carefully designed to avoid lessening the incentive provided by the emission fee. For example, a rebate based on comparing a source's actual emissions and the average emissions for the source category can be designed to be revenue neutral and not diminish the incentive.

Other types of fee programs collect a fee in relation to particular activities or types of

products to encourage the use of alternatives. While these fees are not necessarily directly linked to the total amount of emissions from the activity or product, the relative simplicity of a usage fee may make such programs an effective way to lower emissions. An area source example is a construction permit fee for wood stoves. Such a permit fee is directly related to the potential to emit inherent in a wood stove, and not to the actual emissions from each wood stove in use. Fees on raw materials to a manufacturing process can encourage product reformulation (e.g., fees on solvent sold to makers of architectural coatings) or changes in work practices (e.g., fees on specialty solvents and degreasing compounds used in manufacturing).

Road pricing mechanisms are fee programs that are available to curtail low occupancy vehicle use, fund transportation system improvements and control measures, spatially and temporally shift driving patterns, and attempt to effect land usage changes. Primary examples include increased peak period roadway, bridge, or tunnel tolls (this could also be accomplished with automated vehicle identification systems as well), and toll discounts for pooling arrangements and zero-emitting/low-emitting vehicles.

C. Tax Code and Zoning Provisions

Modifications to existing State or local tax codes, zoning provisions, and land use planning can provide effective economic incentives. Possible modifications to encourage emissions reductions cover a broad span of programs, such as accelerated depreciation of capital equipment used for emissions reductions, corporate income tax deductions or credits for emission abatement costs, property tax waivers based on decreasing emissions, exempting low-emitting products from sales tax, and limitations on parking spaces for office facilities. Mobile source strategies include waiving or lowering any of the following for zero- or low-emitting vehicles: vehicle registration fees, vehicle property tax, sales tax, taxicab license fees, and parking taxes.

D. Subsidies

A State may create incentives for reducing emissions by offering direct subsidies, grants or low-interest loans to encourage the purchase of lower-emitting capital equipment, or a switch to less polluting operating practices. Examples of such programs include clean vehicle conversions, starting shuttle bus or van pool programs, and mass transit fare subsidies. Subsidy programs often suffer from a variety of "free rider" problems. For instance, subsidies for people or firms who were going to switch to the cleaner alternative anyway lower the effectiveness of the subsidy program, or drive up the cost of

achieving a targeted level of emissions reductions.

E. Transportation Control Measures

The following measures are the TCM's listed in section 108(f):

- (i) Programs for improved public transit;
- (ii) Restriction of certain roads or lanes to, or construction of such roads or lanes for use by, passenger buses or high occupancy vehicles;
- (iii) Employer-based transportation management plans, including incentives;
- (iv) Trip-reduction ordinances;
- (v) Traffic flow improvement programs that achieve emission reductions;
- (vi) Fringe and transportation corridor parking facilities serving multiple-occupancy vehicle programs or transit service;
- (vii) Programs to limit or restrict vehicle use in downtown areas or other areas of emission concentration particularly during periods of peak use;
- (viii) Programs for the provision of all forms of high-occupancy, shared-ride services;
- (ix) Programs to limit portions of road surfaces or certain sections of the metropolitan area to the use of non-motorized vehicles or pedestrian use, both as to time and place;
- (x) Programs for secure bicycle storage facilities and other facilities, including bicycle lanes, for the convenience and protection of bicyclists, in both public and private areas;
- (xi) Programs to control extended idling of vehicles;
- (xii) Programs to reduce motor vehicle emissions, consistent with title II, which are caused by extreme cold start conditions;
- (xiii) Employer-sponsored programs to permit flexible work schedules;
- (xiv) Programs and ordinances to facilitate non-automobile travel, provision and utilization of mass transit, and to generally reduce the need for single-occupant vehicle travel, as part of transportation planning and development efforts of a locality, including programs and ordinances applicable to new shopping centers, special events, and other centers of vehicle activity;
- (xv) Programs for new construction and major reconstruction of paths, tracks or areas solely for the use by pedestrian or other non-motorized means of transportation when economically feasible and in the public interest. For purposes of this clause, the Administrator shall also consult with the Secretary of the Interior; and
- (xvi) Programs to encourage the voluntary removal from use and the marketplace of pre-1980 model year light-duty vehicles and pre-1980 model light-duty trucks.

[59 FR 16715, Apr. 7, 1994]

APPENDIX Y TO PART 51—GUIDELINES
FOR BART DETERMINATIONS UNDER
THE REGIONAL HAZE RULE

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I. INTRODUCTION AND OVERVIEW

A. What is the purpose of the guidelines?

The Clean Air Act (CAA), in sections 169A and 169B, contains requirements for the protection of visibility in 156 scenic areas across the United States. To meet the CAA's requirements, we published regulations to protect against a particular type of visibility impairment known as "regional haze." The regional haze rule is found in this part at 40 CFR 51.300 through 51.309. These regulations require, in 40 CFR 51.308(e), that certain types of existing stationary sources of air pollutants install best available retrofit technology (BART). The guidelines are designed to help States and others (1) identify those sources that must comply with the BART requirement, and (2) determine the level of control technology that represents BART for each source.

B. What does the CAA require generally for improving visibility?

Section 169A of the CAA, added to the CAA by the 1977 amendments, requires States to protect and improve visibility in certain scenic areas of national importance. The scenic areas protected by section 169A are "the mandatory Class I Federal Areas * * * where visibility is an important value." In these guidelines, we refer to these as "Class I areas." There are 156 Class I areas, including 47 national parks (under the jurisdiction of the Department of Interior—National Park Service), 108 wilderness areas (under the jurisdiction of the Department of the Interior—Fish and Wildlife Service or the Department of Agriculture—U.S. Forest Service), and one International Park (under the jurisdiction of the Roosevelt-Campobello International Commission). The Federal

Agency with jurisdiction over a particular Class I area is referred to in the CAA as the Federal Land Manager. A complete list of the Class I areas is contained in 40 CFR 81.401 through 81.437, and you can find a map of the Class I areas at the following Internet site: http://www.epa.gov/ttn/oarpg/t1/fr_notices/classimp.gif.

The CAA establishes a national goal of eliminating man-made visibility impairment from all Class I areas. As part of the plan for achieving this goal, the visibility protection provisions in the CAA mandate that EPA issue regulations requiring that States adopt measures in their State implementation plans (SIPs), including long-term strategies, to provide for reasonable progress towards this national goal. The CAA also requires States to coordinate with the Federal Land Managers as they develop their strategies for addressing visibility.

C. What is the BART requirement in the CAA?

1. Under section 169A(b)(2)(A) of the CAA, States must require certain existing stationary sources to install BART. The BART provision applies to “major stationary sources” from 26 identified source categories which have the potential to emit 250 tons per year or more of any air pollutant. The CAA requires only sources which were put in place during a specific 15-year time interval to be subject to BART. The BART provision applies to sources that existed as of the date of the 1977 CAA amendments (that is, August 7, 1977) but which had not been in operation for more than 15 years (that is, not in operation as of August 7, 1962).

2. The CAA requires BART review when any source meeting the above description “emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility” in any Class I area. In identifying a level of control as BART, States are required by section 169A(g) of the CAA to consider:

- (a) The costs of compliance,
- (b) The energy and non-air quality environmental impacts of compliance,
- (c) Any existing pollution control technology in use at the source,
- (d) The remaining useful life of the source, and
- (e) The degree of visibility improvement which may reasonably be anticipated from the use of BART.

3. The CAA further requires States to make BART emission limitations part of their SIPs. As with any SIP revision, States must provide an opportunity for public comment on the BART determinations, and EPA’s action on any SIP revision will be subject to judicial review.

D. What types of visibility problems does EPA address in its regulations?

1. We addressed the problem of visibility in two phases. In 1980, we published regulations addressing what we termed “reasonably attributable” visibility impairment. Reasonably attributable visibility impairment is the result of emissions from one or a few sources that are generally located in close proximity to a specific Class I area. The regulations addressing reasonably attributable visibility impairment are published in 40 CFR 51.300 through 51.307.

2. On July 1, 1999, we amended these regulations to address the second, more common, type of visibility impairment known as “regional haze.” Regional haze is the result of the collective contribution of many sources over a broad region. The regional haze rule slightly modified 40 CFR 51.300 through 51.307, including the addition of a few definitions in §51.301, and added new §§51.308 and 51.309.

E. What are the BART requirements in EPA’s regional haze regulations?

1. In the July 1, 1999 rulemaking, we added a BART requirement for regional haze. We amended the BART requirements in 2005. You will find the BART requirements in 40 CFR 51.308(e). Definitions of terms used in 40 CFR 51.308(e)(1) are found in 40 CFR 51.301.

2. As we discuss in detail in these guidelines, the regional haze rule codifies and clarifies the BART provisions in the CAA. The rule requires that States identify and list “BART-eligible sources,” that is, that States identify and list those sources that fall within the 26 source categories, were put in place during the 15-year window of time from 1962 to 1977, and have potential emissions greater than 250 tons per year. Once the State has identified the BART-eligible sources, the next step is to identify those BART-eligible sources that may “emit any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility.” Under the rule, a source which fits this description is “subject to BART.” For each source subject to BART, 40 CFR 51.308(e)(1)(ii)(A) requires that States identify the level of control representing BART after considering the factors set out in CAA section 169A(g), as follows:

—States must identify the best system of continuous emission control technology for each source subject to BART taking into account the technology available, the costs of compliance, the energy and non-air quality environmental impacts of compliance, any pollution control equipment in use at the source, the remaining useful life of the source, and the degree of visibility improvement that may be expected from available control technology.

3. After a State has identified the level of control representing BART (if any), it must establish an emission limit representing BART and must ensure compliance with that requirement no later than 5 years after EPA approves the SIP. States may establish design, equipment, work practice or other operational standards when limitations on measurement technologies make emission standards infeasible.

F. What is included in the guidelines?

1. The guidelines provide a process for making BART determinations that States can use in implementing the regional haze BART requirements on a source-by-source basis, as provided in 40 CFR 51.308(e)(1). States must follow the guidelines in making BART determinations on a source-by-source basis for 750 megawatt (MW) power plants but are not required to use the process in the guidelines when making BART determinations for other types of sources.

2. The BART analysis process, and the contents of these guidelines, are as follows:

(a) *Identification of all BART-eligible sources.* Section II of these guidelines outlines a step-by-step process for identifying BART-eligible sources.

(b) *Identification of sources subject to BART.* As noted above, sources "subject to BART" are those BART-eligible sources which "emit a pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility in any Class I area." We discuss considerations for identifying sources subject to BART in section III of the guidance.

(c) *The BART determination process.* For each source subject to BART, the next step is to conduct an analysis of emissions control alternatives. This step includes the identification of available, technically feasible retrofit technologies, and for each technology identified, an analysis of the cost of compliance, the energy and non-air quality environmental impacts, and the degree of visibility improvement in affected Class I areas resulting from the use of the control technology. As part of the BART analysis, the State should also take into account the remaining useful life of the source and any existing control technology present at the source. For each source, the State will determine a "best system of continuous emission reduction" based upon its evaluation of these factors. Procedures for the BART determination step are described in section IV of these guidelines.

(d) *Emissions limits.* States must establish emission limits, including a deadline for compliance, consistent with the BART determination process for each source subject to BART. Considerations related to these limits are discussed in section V of these guidelines.

G. Who is the target audience for the guidelines?

1. The guidelines are written primarily for the benefit of State, local and Tribal agencies, and describe a process for making the BART determinations and establishing the emission limitations that must be included in their SIPs or Tribal implementation plans (TIPs). Throughout the guidelines, which are written in a question and answer format, we ask questions "How do I * * *?" and answer with phrases "you should * * *, you must * * *". The "you" means a State, local or Tribal agency conducting the analysis. We have used this format to make the guidelines simpler to understand, but we recognize that States have the authority to require source owners to assume part of the analytical burden, and that there will be differences in how the supporting information is collected and documented. We also recognize that data collection, analysis, and rule development may be performed by Regional Planning Organizations, for adoption within each SIP or TIP.

2. The preamble to the 1999 regional haze rule discussed at length the issue of Tribal implementation of the requirements to submit a plan to address visibility. As explained there, requirements related to visibility are among the programs for which Tribes may be determined eligible and receive authorization to implement under the "Tribal Authority Rule" ("TAR") (40 CFR 49.1 through 49.11). Tribes are not subject to the deadlines for submitting visibility implementation plans and may use a modular approach to CAA implementation. We believe there are very few BART-eligible sources located on Tribal lands. Where such sources exist, the affected Tribe may apply for delegation of implementation authority for this rule, following the process set forth in the TAR.

H. Do EPA regulations require the use of these guidelines?

Section 169A(b) requires us to issue guidelines for States to follow in establishing BART emission limitations for fossil-fuel fired power plants having a capacity in excess of 750 megawatts. This document fulfills that requirement, which is codified in 40 CFR 51.308(e)(1)(ii)(B). The guidelines establish an approach to implementing the requirements of the BART provisions of the regional haze rule; we believe that these procedures and the discussion of the requirements of the regional haze rule and the CAA should be useful to the States. For sources other than 750 MW power plants, however, States retain the discretion to adopt approaches that differ from the guidelines.

II. HOW TO IDENTIFY BART-ELIGIBLE SOURCES

This section provides guidelines on how to identify BART-eligible sources. A BART-eligible source is an existing stationary source

in any of 26 listed categories which meets criteria for startup dates and potential emissions.

A. What are the steps in identifying BART-eligible sources?

Figure 1 shows the steps for identifying whether the source is a “BART-eligible source.”

Step 1: Identify the emission units in the BART categories.

Step 2: Identify the start-up dates of those emission units, and

Step 3: Compare the potential emissions to the 250 ton/yr cutoff.

Figure 1. How to determine whether a source is BART-eligible:

Step 1: Identify emission units in the BART categories

Does the plant contain emissions units in one or more of the 26 source categories?

→ No → Stop

→ Yes → Proceed to Step 2

Step 2: Identify the start-up dates of these emission units

Do any of these emissions units meet the following two tests?

In existence on August 7, 1977

AND

Began operation after August 7, 1962

→ No → Stop

→ Yes → Proceed to Step 3

Step 3: Compare the potential emissions from these emission units to the 250 ton/yr cutoff

Identify the “stationary source” that includes the emission units you identified in Step 2.

Add the current potential emissions from all the emission units identified in Steps 1 and 2 that are included within the “stationary source” boundary.

Are the potential emissions from these units 250 tons per year or more for any visibility-impairing pollutant?

→ No → Stop

→ Yes → These emissions units comprise the “BART-eligible source.”

1. Step 1: Identify Emission Units in the BART Categories

1. The BART requirement only applies to sources in specific categories listed in the CAA. The BART requirement does not apply to sources in other source categories, regardless of their emissions. The listed categories are:

- (1) Fossil-fuel fired steam electric plants of more than 250 million British thermal units (BTU) per hour heat input,
- (2) Coal cleaning plants (thermal dryers),
- (3) Kraft pulp mills,
- (4) Portland cement plants,
- (5) Primary zinc smelters,
- (6) Iron and steel mill plants,

(7) Primary aluminum ore reduction plants,

(8) Primary copper smelters,

(9) Municipal incinerators capable of charging more than 250 tons of refuse per day,

(10) Hydrofluoric, sulfuric, and nitric acid plants,

(11) Petroleum refineries,

(12) Lime plants,

(13) Phosphate rock processing plants,

(14) Coke oven batteries,

(15) Sulfur recovery plants,

(16) Carbon black plants (furnace process),

(17) Primary lead smelters,

(18) Fuel conversion plants,

(19) Sintering plants,

(20) Secondary metal production facilities,

(21) Chemical process plants,

(22) Fossil-fuel boilers of more than 250 million BTUs per hour heat input,

(23) Petroleum storage and transfer facilities with a capacity exceeding 300,000 barrels,

(24) Taconite ore processing facilities,

(25) Glass fiber processing plants, and

(26) Charcoal production facilities.

2. Some plants may have emission units from more than one category, and some emitting equipment may fit into more than one category. Examples of this situation are sulfur recovery plants at petroleum refineries, coke oven batteries and sintering plants at steel mills, and chemical process plants at refineries. For Step 1, you identify all of the emissions units at the plant that fit into one or more of the listed categories. You do not identify emission units in other categories.

Example: A mine is collocated with an electric steam generating plant and a coal cleaning plant. You would identify emission units associated with the electric steam generating plant and the coal cleaning plant, because they are listed categories, but not the mine, because coal mining is not a listed category.

3. The category titles are generally clear in describing the types of equipment to be listed. Most of the category titles are very broad descriptions that encompass all emission units associated with a plant site (for example, “petroleum refining” and “kraft pulp mills”). This same list of categories appears in the PSD regulations. States and source owners need not revisit any interpretations of the list made previously for purposes of the PSD program. We provide the following clarifications for a few of the category titles:

(1) “*Steam electric plants of more than 250 million BTU/hr heat input.*” Because the category refers to “plants,” we interpret this category title to mean that boiler capacities should be aggregated to determine whether the 250 million BTU/hr threshold is reached. This definition includes only those plants that generate electricity for sale. Plants

that cogenerate steam and electricity also fall within the definition of "steam electric plants". Similarly, combined cycle turbines are also considered "steam electric plants" because such facilities incorporate heat recovery steam generators. Simple cycle turbines, in contrast, are not "steam electric plants" because these turbines typically do not generate steam.

Example: A stationary source includes a steam electric plant with three 100 million BTU/hr boilers. Because the aggregate capacity exceeds 250 million BTU/hr for the "plant," these boilers would be identified in Step 2.

(2) "*Fossil-fuel boilers of more than 250 million BTU/hr heat input.*" We interpret this category title to cover only those boilers that are individually greater than 250 million BTU/hr. However, an individual boiler smaller than 250 million BTU/hr should be subject to BART if it is an integral part of a process description at a plant that is in a different BART category—for example, a boiler at a Kraft pulp mill that, in addition to providing steam or mechanical power, uses the waste liquor from the process as a fuel. In general, if the process uses any by-product of the boiler and the boiler's function is to serve the process, then the boiler is integral to the process and should be considered to be part of the process description.

Also, you should consider a multi-fuel boiler to be a "fossil-fuel boiler" if it burns any amount of fossil fuel. You may take federally and State enforceable operational limits into account in determining whether a multi-fuel boiler's fossil fuel capacity exceeds 250 million Btu/hr.

(3) "*Petroleum storage and transfer facilities with a capacity exceeding 300,000 barrels.*" The 300,000 barrel cutoff refers to total facility-wide tank capacity for tanks that were put in place within the 1962–1977 time period, and includes gasoline and other petroleum-derived liquids.

(4) "*Phosphate rock processing plants.*" This category descriptor is broad, and includes all types of phosphate rock processing facilities, including elemental phosphorous plants as well as fertilizer production plants.

(5) "*Charcoal production facilities.*" We interpret this category to include charcoal briquet manufacturing and activated carbon production.

(6) "*Chemical process plants.*" and pharmaceutical manufacturing. Consistent with past policy, we interpret the category "chemical process plants" to include those facilities within the 2-digit Standard Industrial Classification (SIC) code 28. Accordingly, we interpret the term "chemical process plants" to include pharmaceutical manufacturing facilities.

(7) "*Secondary metal production.*" We interpret this category to include nonferrous

metal facilities included within SIC code 3341, and secondary ferrous metal facilities that we also consider to be included within the category "iron and steel mill plants."

(8) "*Primary aluminum ore reduction.*" We interpret this category to include those facilities covered by 40 CFR 60.190, the new source performance standard (NSPS) for primary aluminum ore reduction plants. This definition is also consistent with the definition at 40 CFR 63.840.

2. Step 2: Identify the Start-Up Dates of the Emission Units

1. Emissions units listed under Step 1 are BART-eligible only if they were "in existence" on August 7, 1977 but were not "in operation" before August 7, 1962.

What does "in existence on August 7, 1977" mean?

2. The regional haze rule defines "in existence" to mean that:

"the owner or operator has obtained all necessary preconstruction approvals or permits required by Federal, State, or local air pollution emissions and air quality laws or regulations and either has (1) begun, or caused to begin, a continuous program of physical on-site construction of the facility or (2) entered into binding agreements or contractual obligations, which cannot be canceled or modified without substantial loss to the owner or operator, to undertake a program of construction of the facility to be completed in a reasonable time." 40 CFR 51.301.

As this definition is essentially identical to the definition of "commence construction" as that term is used in the PSD regulations, the two terms mean the same thing. See 40 CFR 51.165(a)(1)(xvi) and 40 CFR 52.21(b)(9). Under this definition, an emissions unit could be "in existence" even if it did not begin operating until several years after 1977.

Example: The owner of a source obtained all necessary permits in early 1977 and entered into binding construction agreements in June 1977. Actual on-site construction began in late 1978, and construction was completed in mid-1979. The source began operating in September 1979. The emissions unit was "in existence" as of August 7, 1977.

Major stationary sources which commenced construction AFTER August 7, 1977 (i.e., major stationary sources which were not "in existence" on August 7, 1977) were subject to new source review (NSR) under the PSD program. Thus, the August 7, 1977 "in existence" test is essentially the same thing as the identification of emissions units that were grandfathered from the NSR review requirements of the 1977 CAA amendments.

3. Sources are not BART-eligible if the only change at the plant during the relevant time period was the addition of pollution controls. For example, if the only change at a copper smelter during the 1962 through 1977 time period was the addition of acid plants for the reduction of SO₂ emissions, these emission controls would not by themselves trigger a BART review.

What does “in operation before August 7, 1962” mean?

An emissions unit that meets the August 7, 1977 “in existence” test is not BART-eligible if it was in operation before August 7, 1962. “In operation” is defined as “engaged in activity related to the primary design function of the source.” This means that a source must have begun actual operations by August 7, 1962 to satisfy this test.

Example: The owner or operator entered into binding agreements in 1960. Actual on-site construction began in 1961, and construction was complete in mid-1962. The source began operating in September 1962. The emissions unit *was not* “in operation” before August 7, 1962 and is therefore subject to BART.

What is a “reconstructed source?”

1. Under a number of CAA programs, an existing source which is completely or substantially rebuilt is treated as a new source. Such “reconstructed” sources are treated as new sources as of the time of the reconstruction. Consistent with this overall approach to reconstructions, the definition of BART-eligible facility (reflected in detail in the definition of “existing stationary facility”) includes consideration of sources that were in operation before August 7, 1962, but were reconstructed during the August 7, 1962 to August 7, 1977 time period.

2. Under the regional haze regulations at 40 CFR 51.301, a reconstruction has taken place if “the fixed capital cost of the new component exceeds 50 percent of the fixed capital cost of a comparable entirely new source.” The rule also states that “[a]ny final decision as to whether reconstruction has occurred must be made in accordance with the provisions of §§60.15 (f)(1) through (3) of this title.” “[T]he provisions of §§60.15(f)(1) through (3)” refers to the general provisions for New Source Performance Standards (NSPS). Thus, the same policies and procedures for identifying reconstructed “affected facilities” under the NSPS program must also be used to identify reconstructed “stationary sources” for purposes of the BART requirement.

3. You should identify reconstructions on an emissions unit basis, rather than on a plantwide basis. That is, you need to identify only the reconstructed emission units meeting the 50 percent cost criterion. You should

include reconstructed emission units in the list of emission units you identified in Step 1. You need consider as possible reconstructions only those emissions units with the potential to emit more than 250 tons per year of any visibility-impairing pollutant.

4. The “in operation” and “in existence” tests apply to reconstructed sources. If an emissions unit was reconstructed and began actual operation before August 7, 1962, it is not BART-eligible. Similarly, any emissions unit for which a reconstruction “commenced” after August 7, 1977, is not BART-eligible.

How are modifications treated under the BART provision?

1. The NSPS program and the major source NSR program both contain the concept of modifications. In general, the term “modification” refers to any physical change or change in the method of operation of an emissions unit that results in an increase in emissions.

2. The BART provision in the regional haze rule contains no explicit treatment of modifications or how modified emissions units, previously subject to the requirement to install best available control technology (BACT), lowest achievable emission rate (LAER) controls, and/or NSPS are treated under the rule. As the BART requirements in the CAA do not appear to provide any exemption for sources which have been modified since 1977, the best interpretation of the CAA visibility provisions is that a subsequent modification does not change a unit’s construction date for the purpose of BART applicability. Accordingly, if an emissions unit began operation before 1962, it is not BART-eligible if it was modified between 1962 and 1977, so long as the modification is not also a “reconstruction.” On the other hand, an emissions unit which began operation within the 1962–1977 time window, but was modified after August 7, 1977, is BART-eligible. We note, however, that if such a modification was a major modification that resulted in the installation of controls, the State will take this into account during the review process and may find that the level of controls already in place are consistent with BART.

3. Step 3: Compare the Potential Emissions to the 250 Ton/Yr Cutoff

The result of Steps 1 and 2 will be a list of emissions units at a given plant site, including reconstructed emissions units, that are within one or more of the BART categories and that were placed into operation within the 1962–1977 time window. The third step is to determine whether the total emissions represent a current potential to emit that is greater than 250 tons per year of any single visibility impairing pollutant. Fugitive

emissions, to the extent quantifiable, must be counted. In most cases, you will add the potential emissions from all emission units on the list resulting from Steps 1 and 2. In a few cases, you may need to determine whether the plant contains more than one “stationary source” as the regional haze rule defines that term, and as we explain further below.

What pollutants should I address?

Visibility-impairing pollutants include the following:

- (1) Sulfur dioxide (SO₂),
- (2) Nitrogen oxides (NO_x), and
- (3) Particulate matter.

You may use PM₁₀ as an indicator for particulate matter in this initial step. [Note that we do not recommend use of total suspended particulates (TSP) as an indicator for particulate matter.] As emissions of PM₁₀ include the components of PM_{2.5} as a subset, there is no need to have separate 250 ton thresholds for PM₁₀ and PM_{2.5}; 250 tons of PM₁₀ represents at most 250 tons of PM_{2.5}, and at most 250 tons of any individual particulate species such as elemental carbon, crustal material, etc.

However, if you determine that a source of particulate matter is BART-eligible, it will be important to distinguish between the fine and coarse particle components of direct particulate emissions in the remainder of the BART analysis, including for the purpose of modeling the source's impact on visibility. This is because although both fine and coarse particulate matter contribute to visibility impairment, the long-range transport of fine particles is of particular concern in the formation of regional haze. Thus, for example, air quality modeling results used in the BART determination will provide a more accurate prediction of a source's impact on visibility if the inputs into the model account for the relative particle size of any directly emitted particulate matter (*i.e.* PM₁₀ vs. PM_{2.5}).

You should exercise judgment in deciding whether the following pollutants impair visibility in an area:

- (4) Volatile organic compounds (VOC), and
- (5) Ammonia and ammonia compounds.

You should use your best judgment in deciding whether VOC or ammonia emissions from a source are likely to have an impact on visibility in an area. Certain types of VOC emissions, for example, are more likely to form secondary organic aerosols than others.¹ Similarly, controlling ammonia emissions in some areas may not have a significant impact on visibility. You need not pro-

vide a formal showing of an individual decision that a source of VOC or ammonia emissions is not subject to BART review. Because air quality modeling may not be feasible for individual sources of VOC or ammonia, you should also exercise your judgment in assessing the degree of visibility impacts due to emissions of VOC and emissions of ammonia or ammonia compounds. You should fully document the basis for judging that a VOC or ammonia source merits BART review, including your assessment of the source's contribution to visibility impairment.

What does the term “potential” emissions mean?

The regional haze rule defines potential to emit as follows:

“Potential to emit” means the maximum capacity of a stationary source to emit a pollutant under its physical and operational design. Any physical or operational limitation on the capacity of the source to emit a pollutant including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitation or the effect it would have on emissions is federally enforceable. Secondary emissions do not count in determining the potential to emit of a stationary source.

The definition of “potential to emit” means that a source which actually emits less than 250 tons per year of a visibility-impairing pollutant is BART-eligible if its emissions would exceed 250 tons per year when operating at its maximum capacity given its physical and operational design (and considering all federally enforceable and State enforceable permit limits.)

Example: A source, while operating at one-fourth of its capacity, emits 75 tons per year of SO₂. If it were operating at 100 percent of its maximum capacity, the source would emit 300 tons per year. Because under the above definition such a source would have “potential” emissions that exceed 250 tons per year, the source (if in a listed category and built during the 1962–1977 time window) would be BART-eligible.

How do I identify whether a plant has more than one “stationary source?”

1. The regional haze rule, in 40 CFR 51.301, defines a stationary source as a “building, structure, facility or installation which emits or may emit any air pollutant.”² The

²NOTE: Most of these terms and definitions are the same for regional haze and the 1980 visibility regulations. For the regional haze rule we use the term “BART-eligible source” rather than “existing stationary facility” to

Continued

¹*Fine particles: Overview of Atmospheric Chemistry, Sources of Emissions, and Ambient Monitoring Data*, Memorandum to Docket OAR 2002–006, April 1, 2005.

rule further defines “building, structure or facility” as:

all of the pollutant-emitting activities which belong to the same industrial grouping, are located on one or more contiguous or adjacent properties, and are under the control of the same person (or persons under common control). Pollutant-emitting activities must be considered as part of the same industrial grouping if they belong to the same Major Group (*i.e.*, which have the same two-digit code) as described in the Standard Industrial Classification Manual, 1972 as amended by the 1977 Supplement (U.S. Government Printing Office stock numbers 4101-0066 and 003-005-00176-0, respectively).

2. In applying this definition, it is necessary to determine which facilities are located on “contiguous or adjacent properties.” Within this contiguous and adjacent area, it is also necessary to group those emission units that are under “common control.” We note that these plant boundary issues and “common control” issues are very similar to those already addressed in implementation of the title V operating permits program and in NSR.

3. For emission units within the “contiguous or adjacent” boundary and under common control, you must group emission units that are within the same industrial grouping (that is, associated with the same 2-digit SIC code) in order to define the stationary source.³ For most plants on the BART source category list, there will only be one 2-digit SIC that applies to the entire plant. For example, all emission units associated with kraft pulp mills are within SIC code 26, and chemical process plants will generally include emission units that are all within SIC code 28. The “2-digit SIC test” applies in the same way as the test is applied in the major source NSR programs.⁴

clarify that only a limited subset of existing stationary sources are subject to BART.

³We recognize that we are in a transition period from the use of the SIC system to a new system called the North American Industry Classification System (NAICS). For purposes of identifying BART-eligible sources, you may use either 2-digit SICs or the equivalent in the NAICS system.

⁴NOTE: The concept of support facility used for the NSR program applies here as well. Support facilities, that is facilities that convey, store or otherwise assist in the production of the principal product, must be grouped with primary facilities even when the facilities fall within separate SIC codes. For purposes of BART reviews, however, such support facilities (a) must be within one of the 26 listed source categories and (b) must have been in existence as of August 7, 1977, and (c) must not have been in operation as of August 7, 1962.

4. For purposes of the regional haze rule, you must group emissions from all emission units put in place within the 1962-1977 time period that are within the 2-digit SIC code, even if those emission units are in different categories on the BART category list.

Examples: A chemical plant which started operations within the 1962 to 1977 time period manufactures hydrochloric acid (within the category title “Hydrochloric, sulfuric, and nitric acid plants”) and various organic chemicals (within the category title “chemical process plants”). All of the emission units are within SIC code 28 and, therefore, all the emission units are considered in determining BART eligibility of the plant. You sum the emissions over all of these emission units to see whether there are more than 250 tons per year of potential emissions.

A steel mill which started operations within the 1962 to 1977 time period includes a sintering plant, a coke oven battery, and various other emission units. All of the emission units are within SIC code 33. You sum the emissions over all of these emission units to see whether there are more than 250 tons per year of potential emissions.

4. Final Step: Identify the Emissions Units and Pollutants That Constitute the BART-Eligible Source

If the emissions from the list of emissions units at a stationary source exceed a potential to emit of 250 tons per year for any visibility-impairing pollutant, then that collection of emissions units is a BART-eligible source.

Example: A stationary source comprises the following two emissions units, with the following potential emissions:

Emissions unit A

200 tons/yr SO₂

150 tons/yr NO_x

25 tons/yr PM

Emissions unit B

100 tons/yr SO₂

75 tons/yr NO_x

10 tons/yr PM

For this example, potential emissions of SO₂ are 300 tons/yr, which exceeds the 250 tons/yr threshold. Accordingly, the entire “stationary source”, that is, emissions units A and B, may be subject to a BART review for SO₂, NO_x, and PM, even though the potential emissions of PM and NO_x at each emissions unit are less than 250 tons/yr each.

Example: The total potential emissions, obtained by adding the potential emissions of all emission units in a listed category at a plant site, are as follows:

200 tons/yr SO₂

150 tons/yr NO_x

25 tons/yr PM

Even though total emissions exceed 250 tons/yr, no individual regulated pollutant exceeds 250 tons/yr and this source is not BART-eligible.

Can States establish de minimis levels of emissions for pollutants at BART-eligible sources?

In order to simplify BART determinations, States may choose to identify de minimis levels of pollutants at BART-eligible sources (but are not required to do so). De minimis values should be identified with the purpose of excluding only those emissions so minimal that they are unlikely to contribute to regional haze. Any de minimis values that you adopt must not be higher than the PSD applicability levels: 40 tons/yr for SO₂ and NO_x and 15 tons/yr for PM₁₀. These de minimis levels may only be applied on a plant-wide basis.

III. HOW TO IDENTIFY SOURCES "SUBJECT TO BART"

Once you have compiled your list of BART-eligible sources, you need to determine whether (1) to make BART determinations for all of them or (2) to consider exempting some of them from BART because they may not reasonably be anticipated to cause or contribute to any visibility impairment in a Class I area. If you decide to make BART determinations for all the BART-eligible sources on your list, you should work with your regional planning organization (RPO) to show that, collectively, they cause or contribute to visibility impairment in at least one Class I area. You should then make individual BART determinations by applying the five statutory factors discussed in Section IV below.

On the other hand, you also may choose to perform an initial examination to determine whether a particular BART-eligible source or group of sources causes or contributes to visibility impairment in nearby Class I areas. If your analysis, or information submitted by the source, shows that an individual source or group of sources (or certain pollutants from those sources) is not reasonably anticipated to cause or contribute to any visibility impairment in a Class I area, then you do not need to make BART determinations for that source or group of sources (or for certain pollutants from those sources). In such a case, the source is not "subject to BART" and you do not need to apply the five statutory factors to make a BART determination. This section of the Guideline discusses several approaches that you can use to exempt sources from the BART determination process.

A. What Steps Do I Follow To Determine Whether a Source or Group of Sources Cause or Contribute to Visibility Impairment for Purposes of BART?

1. How Do I Establish a Threshold?

One of the first steps in determining whether sources cause or contribute to visibility impairment for purposes of BART is to establish a threshold (measured in deciviews) against which to measure the visibility impact of one or more sources. A single source that is responsible for a 1.0 deciview change or more should be considered to "cause" visibility impairment; a source that causes less than a 1.0 deciview change may still contribute to visibility impairment and thus be subject to BART.

Because of varying circumstances affecting different Class I areas, the appropriate threshold for determining whether a source "contributes to any visibility impairment" for the purposes of BART may reasonably differ across States. As a general matter, any threshold that you use for determining whether a source "contributes" to visibility impairment should not be higher than 0.5 deciviews.

In setting a threshold for "contribution," you should consider the number of emissions sources affecting the Class I areas at issue and the magnitude of the individual sources' impacts.⁵ In general, a larger number of sources causing impacts in a Class I area may warrant a lower contribution threshold. States remain free to use a threshold lower than 0.5 deciviews if they conclude that the location of a large number of BART-eligible sources within the State and in proximity to a Class I area justify this approach.⁶

2. What Pollutants Do I Need To Consider?

You must look at SO₂, NO_x, and direct particulate matter (PM) emissions in determining whether sources cause or contribute to visibility impairment, including both PM₁₀ and PM_{2.5}. Consistent with the approach for identifying your BART-eligible sources, you do not need to consider less than de minimis emissions of these pollutants from a source.

⁵We expect that regional planning organizations will have modeling information that identifies sources affecting visibility in individual class I areas.

⁶Note that the contribution threshold should be used to determine whether an individual source is reasonably anticipated to contribute to visibility impairment. You should not aggregate the visibility effects of multiple sources and compare their collective effects against your contribution threshold because this would inappropriately create a "contribute to contribution" test.

As explained in section II, you must use your best judgement to determine whether VOC or ammonia emissions are likely to have an impact on visibility in an area. In addition, although as explained in Section II, you may use PM₁₀ as an indicator for particulate matter in determining whether a source is BART-eligible, in determining whether a source contributes to visibility impairment, you should distinguish between the fine and coarse particle components of direct particulate emissions. Although both fine and coarse particulate matter contribute to visibility impairment, the long-range transport of fine particles is of particular concern in the formation of regional haze. Air quality modeling results used in the BART determination will provide a more accurate prediction of a source's impact on visibility if the inputs into the model account for the relative particle size of any directly emitted particulate matter (i.e. PM₁₀ vs. PM_{2.5}).

3. What Kind of Modeling Should I Use To Determine Which Sources and Pollutants Need Not Be Subject to BART?

This section presents several options for determining that certain sources need not be subject to BART. These options rely on different modeling and/or emissions analysis approaches. They are provided for your guidance. You may also use other reasonable approaches for analyzing the visibility impacts of an individual source or group of sources.

Option 1: Individual Source Attribution Approach (Dispersion Modeling)

You can use dispersion modeling to determine that an individual source cannot reasonably be anticipated to cause or contribute to visibility impairment in a Class I area and thus is not subject to BART. Under this option, you can analyze an individual source's impact on visibility as a result of its emissions of SO₂, NO_x and direct PM emissions. Dispersion modeling cannot currently be used to estimate the predicted impacts on visibility from an individual source's emissions of VOC or ammonia. You may use a more qualitative assessment to determine on a case-by-case basis which sources of VOC or ammonia emissions may be likely to impair visibility and should therefore be subject to BART review, as explained in section II.A.3. above.

You can use CALPUFF⁷ or other appropriate model to predict the visibility impacts from a single source at a Class I area. CALPUFF is the best regulatory modeling application currently available for predicting a single source's contribution to visibility impairment and is currently the only

EPA-approved model for use in estimating single source pollutant concentrations resulting from the long range transport of primary pollutants.⁸ It can also be used for some other purposes, such as the visibility assessments addressed in today's rule, to account for the chemical transformation of SO₂ and NO_x.

There are several steps for making an individual source attribution using a dispersion model:

1. *Develop a modeling protocol.* Some critical items to include in the protocol are the meteorological and terrain data that will be used, as well as the source-specific information (stack height, temperature, exit velocity, elevation, and emission rates of applicable pollutants) and receptor data from appropriate Class I areas. We recommend following EPA's *Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts*⁹ for parameter settings and meteorological data inputs. You may use other settings from those in IWAQM, but you should identify these settings and explain your selection of these settings.

One important element of the protocol is in establishing the receptors that will be used in the model. The receptors that you use should be located in the nearest Class I area with sufficient density to identify the likely visibility effects of the source. For other Class I areas in relatively close proximity to a BART-eligible source, you may model a few strategic receptors to determine whether effects at those areas may be greater than at the nearest Class I area. For example, you might choose to locate receptors at these areas at the closest point to the source, at the highest and lowest elevation in the Class I area, at the IMPROVE monitor, and at the approximate expected plume release height. If the highest modeled effects are observed at the nearest Class I area, you may choose not to analyze the other Class I areas any further as additional analyses might be unwarranted.

You should bear in mind that some receptors within the relevant Class I area may be

⁸The Guideline on Air Quality Models, 40 CFR part 51, appendix W, addresses the regulatory application of air quality models for assessing criteria pollutants under the CAA, and describes further the procedures for using the CALPUFF model, as well as for obtaining approval for the use of other, non-guideline models.

⁹*Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts*, U.S. Environmental Protection Agency, EPA-454/R-98-019, December 1998.

⁷The model code and its documentation are available at no cost for download from <http://www.epa.gov/scram001/tt22.htm#calpuff>.

less than 50 km from the source while other receptors within that same Class I area may be greater than 50 km from the same source. As indicated by the Guideline on Air Quality Models, 40 CFR part 51, appendix W, this situation may call for the use of two different modeling approaches for the same Class I area and source, depending upon the State's chosen method for modeling sources less than 50 km. In situations where you are assessing visibility impacts for source-receptor distances less than 50 km, you should use expert modeling judgment in determining visibility impacts, giving consideration to both CALPUFF and other appropriate methods.

In developing your modeling protocol, you may want to consult with EPA and your regional planning organization (RPO). Up-front consultation will ensure that key technical issues are addressed before you conduct your modeling.

2. *With the accepted protocol and compare the predicted visibility impacts with your threshold for "contribution."* You should calculate daily visibility values for each receptor as the change in deciviews compared against natural visibility conditions. You can use EPA's "Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule," EPA-454/B-03-005 (September 2003) in making this calculation. To determine whether a source may reasonably be anticipated to cause or contribute to visibility impairment at Class I area, you then compare the impacts predicted by the model against the threshold that you have selected.

The emissions estimates used in the models are intended to reflect steady-state operating conditions during periods of high capacity utilization. We do not generally recommend that emissions reflecting periods of start-up, shutdown, and malfunction be used, as such emission rates could produce higher than normal effects than would be typical of most facilities. We recommend that States use the 24 hour average actual emission rate from the highest emitting day of the meteorological period modeled, unless this rate reflects periods start-up, shutdown, or malfunction. In addition, the monthly average relative humidity is used, rather than the daily average humidity—an approach that effectively lowers the peak values in daily model averages.

For these reasons, if you use the modeling approach we recommend, you should compare your "contribution" threshold against the 98th percentile of values. If the 98th percentile value from your modeling is less than your contribution threshold, then you may conclude that the source does not contribute to visibility impairment and is not subject to BART.

Option 2: Use of Model Plants To Exempt Individual Sources With Common Characteristics

Under this option, analyses of model plants could be used to exempt certain BART-eligible sources that share specific characteristics. It may be most useful to use this type of analysis to identify the types of small sources that do not cause or contribute to visibility impairment for purposes of BART, and thus should not be subject to a BART review. Different Class I areas may have different characteristics, however, so you should use care to ensure that the criteria you develop are appropriate for the applicable cases.

In carrying out this approach, you could use modeling analyses of representative plants to reflect groupings of specific sources with important common characteristics. Based on these analyses, you may find that certain types of sources are clearly anticipated to cause or contribute to visibility impairment. You could then choose to categorically require those types of sources to undergo a BART determination. Conversely, you may find based on representative plant analyses that certain types of sources are not reasonably anticipated to cause or contribute to visibility impairment. To do this, you may conduct your own modeling to establish emission levels and distances from Class I areas on which you can rely to exempt sources with those characteristics. For example, based on your modeling you might choose to exempt all NO_x-only sources that emit less than a certain amount per year and are located a certain distance from a Class I area. You could then choose to categorically exempt such sources from the BART determination process.

Our analyses of visibility impacts from model plants provide a useful example of the type of analyses that can be used to exempt categories of sources from BART.¹⁰ In our analyses, we developed model plants (EGUs and non-EGUs), with representative plume and stack characteristics, for use in considering the visibility impact from emission sources of different sizes and compositions at distances of 50, 100 and 200 kilometers from two hypothetical Class I areas (one in the East and one in the West). As the plume and stack characteristics of these model plants were developed considering the broad range of sources within the EGU and non-EGU categories, they do not necessarily represent any specific plant. However, the results of these analyses are instructive in the development of an exemption process for any Class I area.

¹⁰CALPUFF Analysis in Support of the June 2005 Changes to the Regional Haze Rule, U.S. Environmental Protection Agency, June 15, 2005, Docket No. OAR-2002-0076.

In preparing our analyses, we have made a number of assumptions and exercised certain modeling choices; some of these have a tendency to lend conservatism to the results, overstating the likely effects, while others may understate the likely effects. On balance, when all of these factors are considered, we believe that our examples reflect realistic treatments of the situations being modeled. Based on our analyses, we believe that a State that has established 0.5 deciviews as a contribution threshold could reasonably exempt from the BART review process sources that emit less than 500 tons per year of NO_x or SO₂ (or combined NO_x and SO₂), as long as these sources are located more than 50 kilometers from any Class I area; and sources that emit less than 1000 tons per year of NO_x or SO₂ (or combined NO_x and SO₂) that are located more than 100 kilometers from any Class I area. You do, however, have the option of showing other thresholds might also be appropriate given your specific circumstances.

Option 3: Cumulative Modeling To Show That No Sources in a State Are Subject to BART

You may also submit to EPA a demonstration based on an analysis of overall visibility impacts that emissions from BART-eligible sources in your State, considered together, are not reasonably anticipated to cause or contribute to any visibility impairment in a Class I area, and thus no source should be subject to BART. You may do this on a pollutant by pollutant basis or for all visibility-impairing pollutants to determine if emissions from these sources contribute to visibility impairment.

For example, emissions of SO₂ from your BART-eligible sources may clearly cause or contribute to visibility impairment while direct emissions of PM_{2.5} from these sources may not contribute to impairment. If you can make such a demonstration, then you may reasonably conclude that none of your BART-eligible sources are subject to BART for a particular pollutant or pollutants. As noted above, your demonstration should take into account the interactions among pollutants and their resulting impacts on visibility before making any pollutant-specific determinations.

Analyses may be conducted using several alternative modeling approaches. First, you may use the CALPUFF or other appropriate model as described in Option 1 to evaluate the impacts of individual sources on downwind Class I areas, aggregating those impacts to determine the collective contribution of all BART-eligible sources to visibility impairment. You may also use a photochemical grid model. As a general matter, the larger the number of sources being modeled, the more appropriate it may be to use a photochemical grid model. However, be-

cause such models are significantly less sensitive than dispersion models to the contributions of one or a few sources, as well as to the interactions among sources that are widely distributed geographically, if you wish to use a grid model, you should consult with the appropriate EPA Regional Office to develop an appropriate modeling protocol.

IV. THE BART DETERMINATION: ANALYSIS OF BART OPTIONS

This section describes the process for the analysis of control options for sources subject to BART.

A. What factors must I address in the BART review?

The visibility regulations define BART as follows:

Best Available Retrofit Technology (BART) means an emission limitation based on the degree of reduction achievable through the application of the best system of continuous emission reduction for each pollutant which is emitted by . . . [a BART-eligible source]. The emission limitation must be established, on a case-by-case basis, taking into consideration the technology available, the costs of compliance, the energy and non-air quality environmental impacts of compliance, any pollution control equipment in use or in existence at the source, the remaining useful life of the source, and the degree of improvement in visibility which may reasonably be anticipated to result from the use of such technology.

The BART analysis identifies the best system of continuous emission reduction taking into account:

- (1) The available retrofit control options,
- (2) Any pollution control equipment in use at the source (which affects the availability of options and their impacts),
- (3) The costs of compliance with control options,
- (4) The remaining useful life of the facility,
- (5) The energy and non-air quality environmental impacts of control options
- (6) The visibility impacts analysis.

B. What is the scope of the BART review?

Once you determine that a source is subject to BART for a particular pollutant, then for each affected emission unit, you must establish BART for that pollutant. The BART determination must address air pollution control measures for each emissions unit or pollutant emitting activity subject to review.

Example: Plantwide emissions from emission units within the listed categories that began operation within the “time window”

for BART¹¹ are 300 tons/yr of NO_x, 200 tons/yr of SO₂, and 150 tons/yr of primary particulate. Emissions unit A emits 200 tons/yr of NO_x, 100 tons/yr of SO₂, and 100 tons/yr of primary particulate. Other emission units, units B through H, which began operating in 1966, contribute lesser amounts of each pollutant. For this example, a BART review is required for NO_x, SO₂, and primary particulate, and control options must be analyzed for units B through H as well as unit A.

C. How does a BART review relate to Maximum Achievable Control Technology (MACT) Standards under CAA section 112, or to other emission limitations required under the CAA?

For VOC and PM sources subject to MACT standards, States may streamline the analysis by including a discussion of the MACT controls and whether any major new technologies have been developed subsequent to the MACT standards. We believe that there are many VOC and PM sources that are well controlled because they are regulated by the MACT standards, which EPA developed under CAA section 112. For a few MACT standards, this may also be true for SO₂. Any source subject to MACT standards must meet a level that is as stringent as the best-controlled 12 percent of sources in the industry. Examples of these hazardous air pollutant sources which effectively control VOC and PM emissions include (among others) secondary lead facilities, organic chemical plants subject to the hazardous organic NESHAP (HON), pharmaceutical production facilities, and equipment leaks and wastewater operations at petroleum refineries. We believe that, in many cases, it will be unlikely that States will identify emission controls more stringent than the MACT standards without identifying control options that would cost many thousands of dollars per ton. Unless there are new technologies subsequent to the MACT standards which would lead to cost-effective increases in the level of control, you may rely on the MACT standards for purposes of BART.

We believe that the same rationale also holds true for emissions standards developed for municipal waste incinerators under CAA section 111(d), and for many NSR/PSD determinations and NSR/PSD settlement agreements. However, we do not believe that technology determinations from the 1970s or early 1980s, including new source performance standards (NSPS), should be considered to represent best control for existing sources, as best control levels for recent plant retrofits are more stringent than these older levels.

¹¹ That is, emission units that were in existence on August 7, 1977 and which began actual operation on or after August 7, 1962.

Where you are relying on these standards to represent a BART level of control, you should provide the public with a discussion of whether any new technologies have subsequently become available.

D. What Are the Five Basic Steps of a Case-by-Case BART Analysis?

The five steps are:

STEP 1—Identify All¹² Available Retrofit Control Technologies,

STEP 2—Eliminate Technically Infeasible Options,

STEP 3—Evaluate Control Effectiveness of Remaining Control Technologies,

STEP 4—Evaluate Impacts and Document the Results, and

STEP 5—Evaluate Visibility Impacts.

1. STEP 1: How do I identify all available retrofit emission control techniques?

1. Available retrofit control options are those air pollution control technologies with a practical potential for application to the emissions unit and the regulated pollutant under evaluation. Air pollution control technologies can include a wide variety of available methods, systems, and techniques for control of the affected pollutant. Technologies required as BACT or LAER are available for BART purposes and must be included as control alternatives. The control alternatives can include not only existing controls for the source category in question but also take into account technology transfer of controls that have been applied to similar source categories and gas streams. Technologies which have not yet been applied to (or permitted for) full scale operations need not be considered as available; we do not expect the source owner to purchase or construct a process or control device that has not already been demonstrated in practice.

2. Where a NSPS exists for a source category (which is the case for most of the categories affected by BART), you should include a level of control equivalent to the NSPS as one of the control options.¹³ The

¹²In identifying “all” options, you must identify the most stringent option and a reasonable set of options for analysis that reflects a comprehensive list of available technologies. It is not necessary to list all permutations of available control levels that exist for a given technology—the list is complete if it includes the maximum level of control each technology is capable of achieving.

¹³In EPA’s 1980 BART guidelines for reasonably attributable visibility impairment, we concluded that NSPS standards generally, at that time, represented the best level sources could install as BART. In the 20

Continued

NSPS standards are codified in 40 CFR part 60. We note that there are situations where NSPS standards do not require the most stringent level of available control for all sources within a category. For example, post-combustion NO_x controls (the most stringent controls for stationary gas turbines) are not required under subpart GG of the NSPS for Stationary Gas Turbines. However, such controls must still be considered available technologies for the BART selection process.

3. Potentially applicable retrofit control alternatives can be categorized in three ways.

- Pollution prevention: use of inherently lower-emitting processes/practices, including the use of control techniques (*e.g.* low-NO_x burners) and work practices that prevent emissions and result in lower “production-specific” emissions (note that it is not our intent to direct States to switch fuel forms, *e.g.* from coal to gas).

- Use of (and where already in place, improvement in the performance of) add-on controls, such as scrubbers, fabric filters, thermal oxidizers and other devices that control and reduce emissions after they are produced, and

- Combinations of inherently lower-emitting processes and add-on controls.

4. In the course of the BART review, one or more of the available control options may be eliminated from consideration because they are demonstrated to be technically infeasible or to have unacceptable energy, cost, or non-air quality environmental impacts on a case-by-case (or site-specific) basis. However, at the outset, you should initially identify all control options with potential application to the emissions unit under review.

5. We do not consider BART as a requirement to redesign the source when considering available control alternatives. For example, where the source subject to BART is a coal-fired electric generator, we do not require the BART analysis to consider building a natural gas-fired electric turbine although the turbine may be inherently less polluting on a per unit basis.

6. For emission units subject to a BART review, there will often be control measures or

devices already in place. For such emission units, it is important to include control options that involve improvements to existing controls and not to limit the control options only to those measures that involve a complete replacement of control devices.

Example: For a power plant with an existing wet scrubber, the current control efficiency is 66 percent. Part of the reason for the relatively low control efficiency is that 22 percent of the gas stream bypasses the scrubber. A BART review identifies options for improving the performance of the wet scrubber by redesigning the internal components of the scrubber and by eliminating or reducing the percentage of the gas stream that bypasses the scrubber. Four control options are identified: (1) 78 percent control based upon improved scrubber performance while maintaining the 22 percent bypass, (2) 83 percent control based upon improved scrubber performance while reducing the bypass to 15 percent, (3) 93 percent control based upon improving the scrubber performance while eliminating the bypass entirely, (this option results in a “wet stack” operation in which the gas leaving the stack is saturated with water) and (4) 93 percent as in option 3, with the addition of an indirect reheat system to reheat the stack gas above the saturation temperature. You must consider each of these four options in a BART analysis for this source.

7. You are expected to identify potentially applicable retrofit control technologies that represent the full range of demonstrated alternatives. Examples of general information sources to consider include:

- The EPA’s Clean Air Technology Center, which includes the RACT/BACT/LAER Clearinghouse (RBLC);

- State and Local Best Available Control Technology Guidelines—many agencies have online information—for example South Coast Air Quality Management District, Bay Area Air Quality Management District, and Texas Natural Resources Conservation Commission;

- Control technology vendors;
- Federal/State/Local NSR permits and associated inspection/performance test reports;

- Environmental consultants;
- Technical journals, reports and newsletters, air pollution control seminars; and

- The EPA’s NSR bulletin board—<http://www.epa.gov/ttn/nsr>;

- Department of Energy’s Clean Coal Program—technical reports;

- The NO_x Control Technology “Cost Tool”—Clean Air Markets Division Web page—<http://www.epa.gov/airmarkets/arp/nox/controltech.html>;

- Performance of selective catalytic reduction on coal-fired steam generating units—

year period since this guidance was developed, there have been advances in SO₂ control technologies as well as technologies for the control of other pollutants, confirmed by a number of recent retrofits at Western power plants. Accordingly, EPA no longer concludes that the NSPS level of controls automatically represents “the best these sources can install.” Analysis of the BART factors could result in the selection of a NSPS level of control, but you should reach this conclusion only after considering the full range of control options.

final report. OAR/ARD, June 1997 (also available at <http://www.epa.gov/airmarkets/arp/nox/controltech.html>);

- Cost estimates for selected applications of NO_x control technologies on stationary combustion boilers. OAR/ARD June 1997. (Docket for NO_x SIP Call, A-96-56, item II-A-03);

- Investigation of performance and cost of NO_x controls as applied to group 2 boilers. OAR/ARD, August 1996. (Docket for Phase II NO_x rule, A-95-28, item IV-A-4);

- Controlling SO₂ Emissions: A Review of Technologies. EPA-600/R-00-093, USEPA/ORD/NRMRL, October 2000; and

- The OAQPS Control Cost Manual.

You are expected to compile appropriate information from these information sources.

8. There may be situations where a specific set of units within a fenceline constitutes the logical set to which controls would apply and that set of units may or may not all be BART-eligible. (For example, some units in that set may not have been constructed between 1962 and 1977.)

9. If you find that a BART source has controls already in place which are the most stringent controls available (note that this means that all possible improvements to any control devices have been made), then it is not necessary to comprehensively complete each following step of the BART analysis in this section. As long as these most stringent controls available are made federally enforceable for the purpose of implementing BART for that source, you may skip the remaining analyses in this section, including the visibility analysis in step 5. Likewise, if a source commits to a BART determination that consists of the most stringent controls available, then there is no need to complete the remaining analyses in this section.

2. STEP 2: How do I determine whether the options identified in Step 1 are technically feasible?

In Step 2, you evaluate the technical feasibility of the control options you identified in Step 1. You should document a demonstration of technical infeasibility and should explain, based on physical, chemical, or engineering principles, why technical difficulties would preclude the successful use of the control option on the emissions unit under review. You may then eliminate such technically infeasible control options from further consideration in the BART analysis.

In general, what do we mean by technical feasibility?

Control technologies are technically feasible if either (1) they have been installed and operated successfully for the type of source under review under similar conditions, or (2) the technology could be applied to the source under review. Two key con-

cepts are important in determining whether a technology could be applied: "availability" and "applicability." As explained in more detail below, a technology is considered "available" if the source owner may obtain it through commercial channels, or it is otherwise available within the common sense meaning of the term. An available technology is "applicable" if it can reasonably be installed and operated on the source type under consideration. A technology that is available and applicable is technically feasible.

What do we mean by "available" technology?

1. The typical stages for bringing a control technology concept to reality as a commercial product are:

- Concept stage;
- Research and patenting;
- Bench scale or laboratory testing;
- Pilot scale testing;
- Licensing and commercial demonstration; and
- Commercial sales.

2. A control technique is considered available, within the context presented above, if it has reached the stage of licensing and commercial availability. Similarly, we do not expect a source owner to conduct extended trials to learn how to apply a technology on a totally new and dissimilar source type. Consequently, you would not consider technologies in the pilot scale testing stages of development as "available" for purposes of BART review.

3. Commercial availability by itself, however, is not necessarily a sufficient basis for concluding a technology to be applicable and therefore technically feasible. Technical feasibility, as determined in Step 2, also means a control option may reasonably be deployed on or "applicable" to the source type under consideration.

Because a new technology may become available at various points in time during the BART analysis process, we believe that guidelines are needed on when a technology must be considered. For example, a technology may become available during the public comment period on the State's rule development process. Likewise, it is possible that new technologies may become available after the close of the State's public comment period and before submittal of the SIP to EPA, or during EPA's review process on the SIP submittal. In order to provide certainty in the process, all technologies should be considered if available before the close of the State's public comment period. You need not consider technologies that become available after this date. As part of your analysis, you should consider any technologies brought to your attention in public comments. If you disagree with public comments asserting that the technology is available, you should

provide an explanation for the public record as to the basis for your conclusion.

What do we mean by “applicable” technology?

You need to exercise technical judgment in determining whether a control alternative is applicable to the source type under consideration. In general, a commercially available control option will be presumed applicable if it has been used on the same or a similar source type. Absent a showing of this type, you evaluate technical feasibility by examining the physical and chemical characteristics of the pollutant-bearing gas stream, and comparing them to the gas stream characteristics of the source types to which the technology had been applied previously. Deployment of the control technology on a new or existing source with similar gas stream characteristics is generally a sufficient basis for concluding the technology is technically feasible barring a demonstration to the contrary as described below.

What type of demonstration is required if I conclude that an option is not technically feasible?

1. Where you conclude that a control option identified in Step 1 is technically infeasible, you should demonstrate that the option is either commercially unavailable, or that specific circumstances preclude its application to a particular emission unit. Generally, such a demonstration involves an evaluation of the characteristics of the pollutant-bearing gas stream and the capabilities of the technology. Alternatively, a demonstration of technical infeasibility may involve a showing that there are unresolvable technical difficulties with applying the control to the source (*e.g.*, size of the unit, location of the proposed site, operating problems related to specific circumstances of the source, space constraints, reliability, and adverse side effects on the rest of the facility). Where the resolution of technical difficulties is merely a matter of increased cost, you should consider the technology to be technically feasible. The cost of a control alternative is considered later in the process.

2. The determination of technical feasibility is sometimes influenced by recent air quality permits. In some cases, an air quality permit may require a certain level of control, but the level of control in a permit is not expected to be achieved in practice (*e.g.*, a source has received a permit but the project was canceled, or every operating source at that permitted level has been physically unable to achieve compliance with the limit). Where this is the case, you should provide supporting documentation showing why such limits are not technically feasible, and, therefore, why the level of control (but not necessarily the technology) may be

eliminated from further consideration. However, if there is a permit requiring the application of a certain technology or emission limit to be achieved for such technology, this usually is sufficient justification for you to assume the technical feasibility of that technology or emission limit.

3. Physical modifications needed to resolve technical obstacles do not, in and of themselves, provide a justification for eliminating the control technique on the basis of technical infeasibility. However, you may consider the cost of such modifications in estimating costs. This, in turn, may form the basis for eliminating a control technology (see later discussion).

4. Vendor guarantees may provide an indication of commercial availability and the technical feasibility of a control technique and could contribute to a determination of technical feasibility or technical infeasibility, depending on circumstances. However, we do not consider a vendor guarantee alone to be sufficient justification that a control option will work. Conversely, lack of a vendor guarantee by itself does not present sufficient justification that a control option or an emissions limit is technically infeasible. Generally, you should make decisions about technical feasibility based on chemical, and engineering analyses (as discussed above), in conjunction with information about vendor guarantees.

5. A possible outcome of the BART procedures discussed in these guidelines is the evaluation of multiple control technology alternatives which result in essentially equivalent emissions. It is not our intent to encourage evaluation of unnecessarily large numbers of control alternatives for every emissions unit. Consequently, you should use judgment in deciding on those alternatives for which you will conduct the detailed impacts analysis (Step 4 below). For example, if two or more control techniques result in control levels that are essentially identical, considering the uncertainties of emissions factors and other parameters pertinent to estimating performance, you may evaluate only the less costly of these options. You should narrow the scope of the BART analysis in this way only if there is a negligible difference in emissions and energy and non-air quality environmental impacts between control alternatives.

3. STEP 3: How do I evaluate technically feasible alternatives?

Step 3 involves evaluating the control effectiveness of all the technically feasible control alternatives identified in Step 2 for the pollutant and emissions unit under review.

Two key issues in this process include:

(1) Making sure that you express the degree of control using a metric that ensures

an “apples to apples” comparison of emissions performance levels among options, and

(2) Giving appropriate treatment and consideration of control techniques that can operate over a wide range of emission performance levels.

What are the appropriate metrics for comparison?

This issue is especially important when you compare inherently lower-polluting processes to one another or to add-on controls. In such cases, it is generally most effective to express emissions performance as an average steady state emissions level per unit of product produced or processed.

Examples of common metrics:

- Pounds of SO₂ emissions per million Btu heat input, and
- Pounds of NO_x emissions per ton of cement produced.

How do I evaluate control techniques with a wide range of emission performance levels?

1. Many control techniques, including both add-on controls and inherently lower polluting processes, can perform at a wide range of levels. Scrubbers and high and low efficiency electrostatic precipitators (ESPs) are two of the many examples of such control techniques that can perform at a wide range of levels. It is not our intent to require analysis of each possible level of efficiency for a control technique as such an analysis would result in a large number of options. It is important, however, that in analyzing the technology you take into account the most stringent emission control level that the technology is capable of achieving. You should consider recent regulatory decisions and performance data (*e.g.*, manufacturer's data, engineering estimates and the experience of other sources) when identifying an emissions performance level or levels to evaluate.

2. In assessing the capability of the control alternative, latitude exists to consider special circumstances pertinent to the specific source under review, or regarding the prior application of the control alternative. However, you should explain the basis for choosing the alternate level (or range) of control in the BART analysis. Without a showing of differences between the source and other sources that have achieved more stringent emissions limits, you should conclude that the level being achieved by those other sources is representative of the achievable level for the source being analyzed.

3. You may encounter cases where you may wish to evaluate other levels of control in addition to the most stringent level for a given device. While you must consider the most stringent level as one of the control options, you may consider less stringent levels of control as additional options. This would be useful, particularly in cases where the se-

lection of additional options would have widely varying costs and other impacts.

4. Finally, we note that for retrofitting existing sources in addressing BART, you should consider ways to improve the performance of existing control devices, particularly when a control device is not achieving the level of control that other similar sources are achieving in practice with the same device. For example, you should consider requiring those sources with electrostatic precipitators (ESPs) performing below currently achievable levels to improve their performance.

4. STEP 4: For a BART review, what impacts am I expected to calculate and report? What methods does EPA recommend for the impacts analysis?

After you identify the available and technically feasible control technology options, you are expected to conduct the following analyses when you make a BART determination:

Impact analysis part 1: Costs of compliance,

Impact analysis part 2: Energy impacts, and

Impact analysis part 3: Non-air quality environmental impacts.

Impact analysis part 4: Remaining useful life.

In this section, we describe how to conduct each of these three analyses. You are responsible for presenting an evaluation of each impact along with appropriate supporting information. You should discuss and, where possible, quantify both beneficial and adverse impacts. In general, the analysis should focus on the direct impact of the control alternative.

a. Impact analysis part 1: how do I estimate the costs of control?

1. To conduct a cost analysis, you:

- (1) Identify the emissions units being controlled,
- (2) Identify design parameters for emission controls, and
- (3) Develop cost estimates based upon those design parameters.

2. It is important to identify clearly the emission units being controlled, that is, to specify a well-defined area or process segment within the plant. In some cases, multiple emission units can be controlled jointly. However, in other cases, it may be appropriate in the cost analysis to consider whether multiple units will be required to install separate and/or different control devices. The analysis should provide a clear summary list of equipment and the associated control costs. Inadequate documentation of the equipment whose emissions are being controlled is a potential cause for confusion in

comparison of costs of the same controls applied to similar sources.

3. You then specify the control system design parameters. Potential sources of these design parameters include equipment vendors, background information documents used to support NSPS development, control technique guidelines documents, cost manuals developed by EPA, control data in trade publications, and engineering and performance test data. The following are a few examples of design parameters for two example control measures:

| Control device | Examples of design parameters |
|--------------------------------|--|
| Wet Scrubbers | Type of sorbent used (lime, limestone, etc.). Gas pressure drop. Liquid/gas ratio. |
| Selective Catalytic Reduction. | Ammonia to NO _x molar ratio. Pressure drop. Catalyst life. |

4. The value selected for the design parameter should ensure that the control option will achieve the level of emission control being evaluated. You should include in your analysis documentation of your assumptions regarding design parameters. Examples of supporting references would include the EPA OAQPS *Control Cost Manual* (see below) and background information documents used for NSPS and hazardous pollutant emission standards. If the design parameters you specified differ from typical designs, you should document the difference by supplying performance test data for the control technology in question applied to the same source or a similar source.

5. Once the control technology alternatives and achievable emissions performance levels have been identified, you then develop estimates of capital and annual costs. The basis for equipment cost estimates also should be documented, either with data supplied by an equipment vendor (i.e., budget estimates or bids) or by a referenced source (such as the *OAQPS Control Cost Manual*, Fifth Edition, February 1996, EPA 453/B-96-001).¹⁴ In order to maintain and improve consistency, cost estimates should be based on the *OAQPS Control Cost Manual*, where possible.¹⁵ The

¹⁴The *OAQPS Control Cost Manual* is updated periodically. While this citation refers to the latest version at the time this guidance was written, you should use the version that is current as of when you conduct your impact analysis. This document is available at the following Web site: <http://www.epa.gov/ttn/catc/dir1/cs1ch2.pdf>.

¹⁵You should include documentation for any additional information you used for the cost calculations, including any information supplied by vendors that affects your assumptions regarding purchased equipment

Control Cost Manual addresses most control technologies in sufficient detail for a BART analysis. The cost analysis should also take into account any site-specific design or other conditions identified above that affect the cost of a particular BART technology option.

b. What do we mean by cost effectiveness?

Cost effectiveness, in general, is a criterion used to assess the potential for achieving an objective in the most economical way. For purposes of air pollutant analysis, “effectiveness” is measured in terms of tons of pollutant emissions removed, and “cost” is measured in terms of annualized control costs. We recommend two types of cost-effectiveness calculations—average cost effectiveness, and incremental cost effectiveness.

c. How do I calculate average cost effectiveness?

Average cost effectiveness means the total annualized costs of control divided by annual emissions reductions (the difference between baseline annual emissions and the estimate of emissions after controls), using the following formula:

Average cost effectiveness (dollars per ton removed) = $\frac{\text{Control option annualized cost}^{16}}{\text{Baseline annual emissions—Annual emissions with Control option}}$

Baseline annual emissions—Annual emissions with Control option

Because you calculate costs in (annualized) dollars per year (\$/yr) and because you calculate emissions rates in tons per year (tons/yr), the result is an average cost-effectiveness number in (annualized) dollars per ton (\$/ton) of pollutant removed.

d. How do I calculate baseline emissions?

1. The baseline emissions rate should represent a realistic depiction of anticipated annual emissions for the source. In general, for the existing sources subject to BART, you will estimate the anticipated annual emissions based upon actual emissions from a baseline period.

2. When you project that future operating parameters (e.g., limited hours of operation or capacity utilization, type of fuel, raw materials or product mix or type) will differ from past practice, and if this projection has a deciding effect in the BART determination,

costs, equipment life, replacement of major components, and any other element of the calculation that differs from the *Control Cost Manual*.

¹⁶Whenever you calculate or report annual costs, you should indicate the year for which the costs are estimated. For example, if you use the year 2000 as the basis for cost comparisons, you would report that an annualized cost of \$20 million would be: \$20 million (year 2000 dollars).

then you must make these parameters or assumptions into enforceable limitations. In the absence of enforceable limitations, you calculate baseline emissions based upon continuation of past practice.

3. For example, the baseline emissions calculation for an emergency standby generator may consider the fact that the source owner would not operate more than past practice of 2 weeks a year. On the other hand, baseline emissions associated with a base-loaded turbine should be based on its past practice which would indicate a large number of hours of operation. This produces a significantly higher level of baseline emissions than in the case of the emergency/standby unit and results in more cost-effective controls. As a consequence of the dissimilar baseline emissions, BART for the two cases could be very different.

e. How do I calculate incremental cost effectiveness?

1. In addition to the average cost effectiveness of a control option, you should also calculate incremental cost effectiveness. You should consider the incremental cost effectiveness in combination with the average cost effectiveness when considering whether to eliminate a control option. The incremental cost effectiveness calculation compares the costs and performance level of a control option to those of the next most stringent option, as shown in the following formula (with respect to cost per emissions reduction):

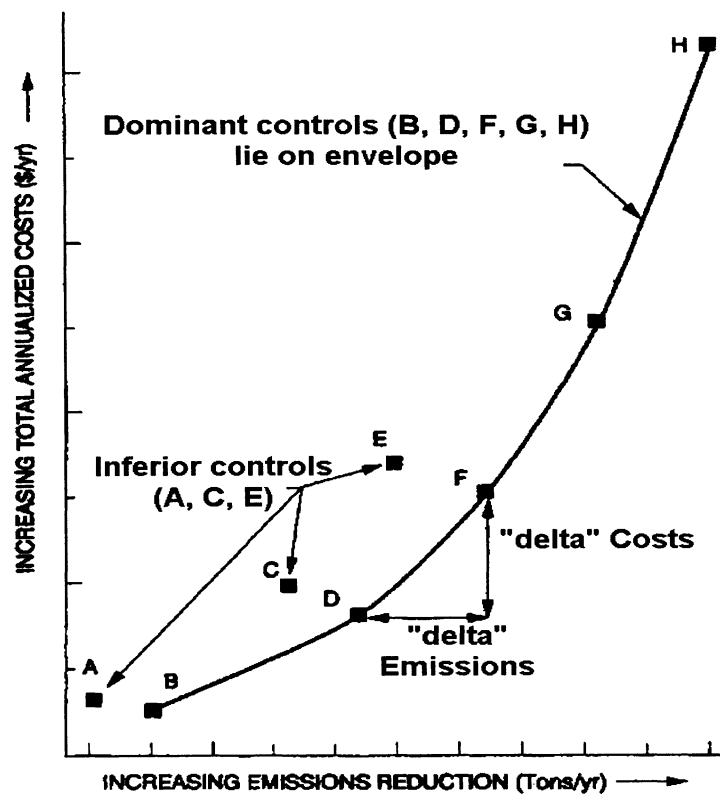
Incremental Cost Effectiveness (dollars per incremental ton removed) = (Total annualized costs of control option) – (Total annualized costs of next control option) ÷ (Control option annual emissions) – (Next control option annual emissions)

Example 1: Assume that Option F on Figure 2 has total annualized costs of \$1 million to reduce 2000 tons of a pollutant, and that Option D on Figure 2 has total annualized costs

of \$500,000 to reduce 1000 tons of the same pollutant. The incremental cost effectiveness of Option F relative to Option D is (\$1 million – \$500,000) divided by (2000 tons – 1000 tons), or \$500,000 divided by 1000 tons, which is \$500/ton.

Example 2: Assume that two control options exist: Option 1 and Option 2. Option 1 achieves a 1,000 ton/yr reduction at an annualized cost of \$1,900,000. This represents an average cost of (\$1,900,000/1,000 tons) = \$1,900/ton. Option 2 achieves a 980 tons/yr reduction at an annualized cost of \$1,500,000. This represents an average cost of (\$1,500,000/980 tons) = \$1,531/ton. The incremental cost effectiveness of Option 1 relative to Option 2 is (\$1,900,000 – \$1,500,000) divided by (1,000 tons – 980 tons). The adoption of Option 1 instead of Option 2 results in an incremental emission reduction of 20 tons per year at an additional cost of \$400,000 per year. The incremental cost of Option 1, then, is \$20,000 per ton – 11 times the average cost of \$1,900 per ton. While \$1,900 per ton may still be deemed reasonable, it is useful to consider both the average and incremental cost in making an overall cost-effectiveness finding. Of course, there may be other differences between these options, such as, energy or water use, or non-air environmental effects, which also should be considered in selecting a BART technology.

2. You should exercise care in deriving incremental costs of candidate control options. Incremental cost-effectiveness comparisons should focus on annualized cost and emission reduction differences between “dominant” alternatives. To identify dominant alternatives, you generate a graphical plot of total annualized costs for total emissions reductions for all control alternatives identified in the BART analysis, and by identifying a “least-cost envelope” as shown in Figure 2. (A “least-cost envelope” represents the set of options that should be dominant in the choice of a specific option.)



Example: Eight technically feasible control options for analysis are listed. These are represented as A through H in Figure 2. The dominant set of control options, B, D, F, G, and H, represent the least-cost envelope, as we depict by the cost curve connecting them. Points A, C and E are inferior options, and you should not use them in calculating incremental cost effectiveness. Points A, C and E represent inferior controls because B will buy more emissions reductions for less money than A; and similarly, D and F will buy more reductions for less money than C and E, respectively.

3. In calculating incremental costs, you:

(1) Array the control options in ascending order of annualized total costs,

(2) Develop a graph of the most reasonable smooth curve of the control options, as shown in Figure 2. This is to show the "least-cost envelope" discussed above; and

(3) Calculate the incremental cost effectiveness for each dominant option, which is the difference in total annual costs between that option and the next most stringent option, divided by the difference in emissions,

after controls have been applied, between those two control options. For example, using Figure 2, you would calculate incremental cost effectiveness for the difference between options B and D, options D and F, options F and G, and options G and H.

4. A comparison of incremental costs can also be useful in evaluating the viability of a specific control option over a range of efficiencies. For example, depending on the capital and operational cost of a control device, total and incremental cost may vary significantly (either increasing or decreasing) over the operational range of a control device. Also, the greater the number of possible control options that exist, the more weight should be given to the incremental costs vs. average costs. It should be noted that average and incremental cost effectiveness are identical when only one candidate control option is known to exist.

5. You should exercise caution not to misuse these techniques. For example, you may be faced with a choice between two available control devices at a source, control A and control B, where control B achieves slightly

greater emission reductions. The average cost (total annual cost/total annual emission reductions) for each may be deemed to be reasonable. However, the incremental cost (total annual cost_{A - B}/total annual emission reductions_{A - B}) of the additional emission reductions to be achieved by control B may be very great. In such an instance, it may be inappropriate to choose control B, based on its high incremental costs, even though its average cost may be considered reasonable.

6. In addition, when you evaluate the average or incremental cost effectiveness of a control alternative, you should make reasonable and supportable assumptions regarding control efficiencies. An unrealistically low assessment of the emission reduction potential of a certain technology could result in inflated cost-effectiveness figures.

f. What other information should I provide in the cost impacts analysis?

You should provide documentation of any unusual circumstances that exist for the source that would lead to cost-effectiveness estimates that would exceed that for recent retrofits. This is especially important in cases where recent retrofits have cost-effectiveness values that are within what has been considered a reasonable range, but your analysis concludes that costs for the source being analyzed are not considered reasonable. (A reasonable range would be a range that is consistent with the range of cost effectiveness values used in other similar permit decisions over a period of time.)

Example: In an arid region, large amounts of water are needed for a scrubbing system. Acquiring water from a distant location could greatly increase the cost per ton of emissions reduced of wet scrubbing as a control option.

g. What other things are important to consider in the cost impacts analysis?

In the cost analysis, you should take care not to focus on incomplete results or partial calculations. For example, large capital costs for a control option alone would not preclude selection of a control measure if large emissions reductions are projected. In such a case, low or reasonable cost effectiveness numbers may validate the option as an appropriate BART alternative irrespective of the large capital costs. Similarly, projects with relatively low capital costs may not be cost effective if there are few emissions reduced.

h. Impact analysis part 2: How should I analyze and report energy impacts?

1. You should examine the energy requirements of the control technology and determine whether the use of that technology results in energy penalties or benefits. A source owner may, for example, benefit from

the combustion of a concentrated gas stream rich in volatile organic compounds; on the other hand, more often extra fuel or electricity is required to power a control device or incinerate a dilute gas stream. If such benefits or penalties exist, they should be quantified to the extent practicable. Because energy penalties or benefits can usually be quantified in terms of additional cost or income to the source, the energy impacts analysis can, in most cases, simply be factored into the cost impacts analysis. The fact of energy use in and of itself does not disqualify a technology.

2. Your energy impact analysis should consider only direct energy consumption and not indirect energy impacts. For example, you could estimate the direct energy impacts of the control alternative in units of energy consumption at the source (*e.g.*, BTU, kWh, barrels of oil, tons of coal). The energy requirements of the control options should be shown in terms of total (and in certain cases, also incremental) energy costs per ton of pollutant removed. You can then convert these units into dollar costs and, where appropriate, factor these costs into the control cost analysis.

3. You generally do not consider indirect energy impacts (such as energy to produce raw materials for construction of control equipment). However, if you determine, either independently or based on a showing by the source owner, that the indirect energy impact is unusual or significant and that the impact can be well quantified, you may consider the indirect impact.

4. The energy impact analysis may also address concerns over the use of locally scarce fuels. The designation of a scarce fuel may vary from region to region. However, in general, a scarce fuel is one which is in short supply locally and can be better used for alternative purposes, or one which may not be reasonably available to the source either at the present time or in the near future.

5. Finally, the energy impacts analysis may consider whether there are relative differences between alternatives regarding the use of locally or regionally available coal, and whether a given alternative would result in significant economic disruption or unemployment. For example, where two options are equally cost effective and achieve equivalent or similar emissions reductions, one option may be preferred if the other alternative results in significant disruption or unemployment.

i. Impact analysis part 3: How do I analyze "non-air quality environmental impacts?"

1. In the non-air quality related environmental impacts portion of the BART analysis, you address environmental impacts other than air quality due to emissions of the pollutant in question. Such environmental impacts include solid or hazardous

waste generation and discharges of polluted water from a control device.

2. You should identify any significant or unusual environmental impacts associated with a control alternative that have the potential to affect the selection or elimination of a control alternative. Some control technologies may have potentially significant secondary environmental impacts. Scrubber effluent, for example, may affect water quality and land use. Alternatively, water availability may affect the feasibility and costs of wet scrubbers. Other examples of secondary environmental impacts could include hazardous waste discharges, such as spent catalysts or contaminated carbon. Generally, these types of environmental concerns become important when sensitive site-specific receptors exist or when the incremental emissions reductions potential of the more stringent control is only marginally greater than the next most-effective option. However, the fact that a control device creates liquid and solid waste that must be disposed of does not necessarily argue against selection of that technology as BART, particularly if the control device has been applied to similar facilities elsewhere and the solid or liquid waste is similar to those other applications. On the other hand, where you or the source owner can show that unusual circumstances at the proposed facility create greater problems than experienced elsewhere, this may provide a basis for the elimination of that control alternative as BART.

3. The procedure for conducting an analysis of non-air quality environmental impacts should be made based on a consideration of site-specific circumstances. If you propose to adopt the most stringent alternative, then it is not necessary to perform this analysis of environmental impacts for the entire list of technologies you ranked in Step 3. In general, the analysis need only address those control alternatives with any significant or unusual environmental impacts that have the potential to affect the selection of a control alternative, or elimination of a more stringent control alternative. Thus, any important relative environmental impacts (both positive and negative) of alternatives can be compared with each other.

4. In general, the analysis of impacts starts with the identification and quantification of the solid, liquid, and gaseous discharges from the control device or devices under review. Initially, you should perform a qualitative or semi-quantitative screening to narrow the analysis to discharges with potential for causing adverse environmental effects. Next, you should assess the mass and composition of any such discharges and quantify them to the extent possible, based on readily available information. You should also assemble pertinent information about the public or

environmental consequences of releasing these materials.

j. Impact analysis part 4: What are examples of non-air quality environmental impacts?

The following are examples of how to conduct non-air quality environmental impacts:

(1) *Water Impact*

You should identify the relative quantities of water used and water pollutants produced and discharged as a result of the use of each alternative emission control system. Where possible, you should assess the effect on ground water and such local surface water quality parameters as pH, turbidity, dissolved oxygen, salinity, toxic chemical levels, temperature, and any other important considerations. The analysis could consider whether applicable water quality standards will be met and the availability and effectiveness of various techniques to reduce potential adverse effects.

(2) *Solid Waste Disposal Impact*

You could also compare the quality and quantity of solid waste (e.g., sludges, solids) that must be stored and disposed of or recycled as a result of the application of each alternative emission control system. You should consider the composition and various other characteristics of the solid waste (such as permeability, water retention, rewetting of dried material, compression strength, leachability of dissolved ions, bulk density, ability to support vegetation growth and hazardous characteristics) which are significant with regard to potential surface water pollution or transport into and contamination of subsurface waters or aquifers.

(3) *Irreversible or Irrecoverable Commitment of Resources*

You may consider the extent to which the alternative emission control systems may involve a trade-off between short-term environmental gains at the expense of long-term environmental losses and the extent to which the alternative systems may result in irreversible or irretrievable commitment of resources (for example, use of scarce water resources).

(4) *Other Adverse Environmental Impacts*

You may consider significant differences in noise levels, radiant heat, or dissipated static electrical energy of pollution control alternatives. Other examples of non-air quality environmental impacts would include hazardous waste discharges such as spent catalysts or contaminated carbon.

k. How do I take into account a project's "remaining useful life" in calculating control costs?

1. You may decide to treat the requirement to consider the source's "remaining useful life" of the source for BART determinations as one element of the overall cost analysis. The "remaining useful life" of a source, if it

represents a relatively short time period, may affect the annualized costs of retrofit controls. For example, the methods for calculating annualized costs in EPA's *OAQPS Control Cost Manual* require the use of a specified time period for amortization that varies based upon the type of control. If the remaining useful life will clearly exceed this time period, the remaining useful life has essentially no effect on control costs and on the BART determination process. Where the remaining useful life is less than the time period for amortizing costs, you should use this shorter time period in your cost calculations.

2. For purposes of these guidelines, the remaining useful life is the difference between:

(1) The date that controls will be put in place (capital and other construction costs incurred before controls are put in place can be rolled into the first year, as suggested in EPA's *OAQPS Control Cost Manual*); you are conducting the BART analysis; and

(2) The date the facility permanently stops operations. Where this affects the BART determination, this date should be assured by a federally- or State-enforceable restriction preventing further operation.

3. We recognize that there may be situations where a source operator intends to shut down a source by a given date, but wishes to retain the flexibility to continue operating beyond that date in the event, for example, that market conditions change. Where this is the case, your BART analysis may account for this, but it must maintain consistency with the statutory requirement to install BART within 5 years. Where the source chooses not to accept a federally enforceable condition requiring the source to shut down by a given date, it is necessary to determine whether a reduced time period for the remaining useful life changes the level of controls that would have been required as BART.

If the reduced time period does change the level of BART controls, you may identify, and include as part of the BART emission limitation, the more stringent level of control that would be required as BART if there were no assumption that reduced the remaining useful life. You may incorporate into the BART emission limit this more stringent level, which would serve as a contingency should the source continue operating more than 5 years after the date EPA approves the relevant SIP. The source would not be allowed to operate after the 5-year mark without such controls. If a source does operate after the 5-year mark without BART in place, the source is considered to be in violation of the BART emissions limit for each day of operation.

5. Step 5: How should I determine visibility impacts in the BART determination?

The following is an approach you may use to determine visibility impacts (the degree of visibility improvement for each source subject to BART) for the BART determination. Once you have determined that your source or sources are subject to BART, you must conduct a visibility improvement determination for the source(s) as part of the BART determination. When making this determination, we believe you have flexibility in setting absolute thresholds, target levels of improvement, or *de minimis* levels since the deciview improvement must be weighed among the five factors, and you are free to determine the weight and significance to be assigned to each factor. For example, a 0.3 deciview improvement may merit a stronger weighting in one case versus another, so one "bright line" may not be appropriate. [Note that if sources have elected to apply the most stringent controls available, consistent with the discussion in section E. step 1. below, you need not conduct, or require the source to conduct, an air quality modeling analysis for the purpose of determining its visibility impacts.]

Use CALPUFF,¹⁷ or other appropriate dispersion model to determine the visibility improvement expected at a Class I area from the potential BART control technology applied to the source. Modeling should be conducted for SO₂, NO_x, and direct PM emissions (PM_{2.5} and/or PM₁₀). If the source is making the visibility determination, you should review and approve or disapprove of the source's analysis before making the expected improvement determination. There are several steps for determining the visibility impacts from an individual source using a dispersion model:

- Develop a modeling protocol.

Some critical items to include in a modeling protocol are meteorological and terrain data, as well as source-specific information (stack height, temperature, exit velocity, elevation, and allowable and actual emission rates of applicable pollutants), and receptor data from appropriate Class I areas. We recommend following EPA's *Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts*¹⁸ for parameter settings and meteorological data inputs; the use of other settings from

¹⁷The model code and its documentation are available at no cost for download from <http://www.epa.gov/scram001/tt22.htm#calpuff>.

¹⁸*Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts*, U.S. Environmental Protection Agency, EPA-454/R-98-019, December 1998.

those in IWAQM should be identified and explained in the protocol.

One important element of the protocol is in establishing the receptors that will be used in the model. The receptors that you use should be located in the nearest Class I area with sufficient density to identify the likely visibility effects of the source. For other Class I areas in relatively close proximity to a BART-eligible source, you may model a few strategic receptors to determine whether effects at those areas may be greater than at the nearest Class I area. For example, you might choose to locate receptors at these areas at the closest point to the source, at the highest and lowest elevation in the Class I area, at the IMPROVE monitor, and at the approximate expected plume release height. If the highest modeled effects are observed at the nearest Class I area, you may choose not to analyze the other Class I areas any further as additional analyses might be unwarranted.

You should bear in mind that some receptors within the relevant Class I area may be less than 50 km from the source while other receptors within that same Class I area may be greater than 50 km from the same source. As indicated by the *Guideline on Air Quality Models*, this situation may call for the use of two different modeling approaches for the same Class I area and source, depending upon the State's chosen method for modeling sources less than 50 km. In situations where you are assessing visibility impacts for source-receptor distances less than 50 km, you should use expert modeling judgment in determining visibility impacts, giving consideration to both CALPUFF and other EPA-approved methods.

In developing your modeling protocol, you may want to consult with EPA and your regional planning organization (RPO). Up-front consultation will ensure that key technical issues are addressed before you conduct your modeling.

- For each source, run the model, at pre-control and post-control emission rates according to the accepted methodology in the protocol.

Use the 24-hour average actual emission rate from the highest emitting day of the meteorological period modeled (for the pre-control scenario). Calculate the model results for each receptor as the change in deciviews compared against natural visibility conditions. Post-control emission rates are calculated as a percentage of pre-control emission rates. For example, if the 24-hr pre-control emission rate is 100 lb/hr of SO₂, then the post control rate is 5 lb/hr if the control efficiency being evaluated is 95 percent.

- Make the net visibility improvement determination.

Assess the visibility improvement based on the modeled change in visibility impacts for

the pre-control and post-control emission scenarios. You have flexibility to assess visibility improvements due to BART controls by one or more methods. You may consider the frequency, magnitude, and duration components of impairment. Suggestions for making the determination are:

- Use of a comparison threshold, as is done for determining if BART-eligible sources should be subject to a BART determination. Comparison thresholds can be used in a number of ways in evaluating visibility improvement (e.g. the number of days or hours that the threshold was exceeded, a single threshold for determining whether a change in impacts is significant, or a threshold representing an x percent change in improvement).

- Compare the 98th percent days for the pre- and post-control runs.

Note that each of the modeling options may be supplemented with source apportionment data or source apportionment modeling.

E. How do I select the "best" alternative, using the results of Steps 1 through 5?

1. Summary of the Impacts Analysis

From the alternatives you evaluated in Step 3, we recommend you develop a chart (or charts) displaying for each of the alternatives:

- (1) Expected emission rate (tons per year, pounds per hour);
- (2) Emissions performance level (e.g., percent pollutant removed, emissions per unit product, lb/MMBtu, ppm);
- (3) Expected emissions reductions (tons per year);
- (4) Costs of compliance—total annualized costs (\$), cost effectiveness (\$/ton), and incremental cost effectiveness (\$/ton), and/or any other cost-effectiveness measures (such as \$/deciview);
- (5) Energy impacts;
- (6) Non-air quality environmental impacts; and
- (7) Modeled visibility impacts.

2. Selecting a "best" alternative

1. You have discretion to determine the order in which you should evaluate control options for BART. Whatever the order in which you choose to evaluate options, you should always (1) display the options evaluated; (2) identify the average and incremental costs of each option; (3) consider the energy and non-air quality environmental impacts of each option; (4) consider the remaining useful life; and (5) consider the modeled visibility impacts. You should provide a justification for adopting the technology that you select as the "best" level of control, including an explanation of the CAA factors that led you to choose that option over other control levels.

2. In the case where you are conducting a BART determination for two regulated pollutants on the same source, if the result is two different BART technologies that do not work well together, you could then substitute a different technology or combination of technologies.

3. In selecting a "best" alternative, should I consider the affordability of controls?

1. Even if the control technology is cost effective, there may be cases where the installation of controls would affect the viability of continued plant operations.

2. There may be unusual circumstances that justify taking into consideration the conditions of the plant and the economic effects of requiring the use of a given control technology. These effects would include effects on product prices, the market share, and profitability of the source. Where there are such unusual circumstances that are judged to affect plant operations, you may take into consideration the conditions of the plant and the economic effects of requiring the use of a control technology. Where these effects are judged to have a severe impact on plant operations you may consider them in the selection process, but you may wish to provide an economic analysis that demonstrates, in sufficient detail for public review, the specific economic effects, parameters, and reasoning. (We recognize that this review process must preserve the confidentiality of sensitive business information). Any analysis may also consider whether other competing plants in the same industry have been required to install BART controls if this information is available.

4. Sulfur dioxide limits for utility boilers

You must require 750 MW power plants to meet specific control levels for SO₂ of either 95 percent control or 0.15 lbs/MMBtu, for each EGU greater than 200 MW that is currently uncontrolled unless you determine that an alternative control level is justified based on a careful consideration of the statutory factors. Thus, for example, if the source demonstrates circumstances affecting its ability to cost-effectively reduce its emissions, you should take that into account in determining whether the presumptive levels of control are appropriate for that facility. For a currently uncontrolled EGU greater than 200 MW in size, but located at a power plant smaller than 750 MW in size, such controls are generally cost-effective and could be used in your BART determination considering the five factors specified in CAA section 169A(g)(2). While these levels may represent current control capabilities, we expect that scrubber technology will continue to improve and control costs continue to decline. You should be sure to consider the level of control that is currently best achieved

at the time that you are conducting your BART analysis.

For coal-fired EGUs with existing post-combustion SO₂ controls achieving less than 50 percent removal efficiencies, we recommend that you evaluate constructing a new FGD system to meet the same emission limits as above (95 percent removal or 0.15 lb/mmBtu), in addition to the evaluation of scrubber upgrades discussed below. For oil-fired units, regardless of size, you should evaluate limiting the sulfur content of the fuel oil burned to 1 percent or less by weight.

For those BART-eligible EGUs with pre-existing post-combustion SO₂ controls achieving removal efficiencies of at least 50 percent, your BART determination should consider cost effective scrubber upgrades designed to improve the system's overall SO₂ removal efficiency. There are numerous scrubber enhancements available to upgrade the average removal efficiencies of all types of existing scrubber systems. We recommend that as you evaluate the definition of "upgrade," you evaluate options that not only improve the design removal efficiency of the scrubber vessel itself, but also consider upgrades that can improve the overall SO₂ removal efficiency of the scrubber system. Increasing a scrubber system's reliability, and conversely decreasing its downtime, by way of optimizing operation procedures, improving maintenance practices, adjusting scrubber chemistry, and increasing auxiliary equipment redundancy, are all ways to improve average SO₂ removal efficiencies.

We recommend that as you evaluate the performance of existing wet scrubber systems, you consider some of the following upgrades, in no particular order, as potential scrubber upgrades that have been proven in the industry as cost effective means to increase overall SO₂ removal of wet systems:

- (a) Elimination of Bypass Reheat;
- (b) Installation of Liquid Distribution Rings;
- (c) Installation of Perforated Trays;
- (d) Use of Organic Acid Additives;
- (e) Improve or Upgrade Scrubber Auxiliary System Equipment;
- (f) Redesign Spray Header or Nozzle Configuration.

We recommend that as you evaluate upgrade options for dry scrubber systems, you should consider the following cost effective upgrades, in no particular order:

- (a) Use of Performance Additives;
- (b) Use of more Reactive Sorbent;
- (c) Increase the Pulverization Level of Sorbent;
- (d) Engineering redesign of atomizer or slurry injection system.

You should evaluate scrubber upgrade options based on the 5 step BART analysis process.

5. Nitrogen oxide limits for utility boilers

You should establish specific numerical limits for NO_x control for each BART determination. For power plants with a generating capacity in excess of 750 MW currently using selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) for part of the year, you should presume that use of those same controls year-round is BART. For other sources currently using SCR or SNCR to reduce NO_x emissions during part of the year, you should carefully consider requiring the use of these controls year-round as the additional costs of operating the equipment throughout the year would be relatively modest.

For coal-fired EGUs greater than 200 MW located at greater than 750 MW power plants and operating without post-combustion controls (*i.e.* SCR or SNCR), we have provided presumptive NO_x limits, differentiated by

boiler design and type of coal burned. You may determine that an alternative control level is appropriate based on a careful consideration of the statutory factors. For coal-fired EGUs greater than 200 MW located at power plants 750 MW or less in size and operating without post-combustion controls, you should likewise presume that these same levels are cost-effective. You should require such utility boilers to meet the following NO_x emission limits, unless you determine that an alternative control level is justified based on consideration of the statutory factors. The following NO_x emission rates were determined based on a number of assumptions, including that the EGU boiler has enough volume to allow for installation and effective operation of separated overfire air ports. For boilers where these assumptions are incorrect, these emission limits may not be cost-effective.

TABLE 1—PRESUMPTIVE NO_x EMISSION LIMITS FOR BART-ELIGIBLE COAL-FIRED UNITS.¹⁹

| Unit type | Coal type | NO _x presumptive limit (lb/mmbtu) ²⁰ |
|-----------------------------------|----------------------|--|
| Dry-bottom wall-fired | Bituminous | 0.39 |
| | Sub-bituminous | 0.23 |
| | Lignite | 0.29 |
| Tangential-fired | Bituminous | 0.28 |
| | Sub-bituminous | 0.15 |
| | Lignite | 0.17 |
| Cell Burners | Bituminous | 0.40 |
| | Sub-bituminous | 0.45 |
| Dry-turbo-fired | Bituminous | 0.32 |
| | Sub-bituminous | 0.23 |
| Wet-bottom tangential-fired | Bituminous | 0.62 |

¹⁹ No Cell burners, dry-turbo-fired units, nor wet-bottom tangential-fired units burning lignite were identified as BART-eligible, thus no presumptive limit was determined. Similarly, no wet-bottom tangential-fired units burning sub-bituminous were identified as BART-eligible.

²⁰ These limits reflect the design and technological assumptions discussed in the technical support document for NO_x limits for these guidelines. See *Technical Support Document for BART NO_x Limits for Electric Generating Units and Technical Support Document for BART NO_x Limits for Electric Generating Units Excel Spreadsheet*, Memorandum to Docket OAR 2002–0076, April 15, 2005.

Most EGUs can meet these presumptive NO_x limits through the use of current combustion control technology, *i.e.* the careful control of combustion air and low-NO_x burners. For units that cannot meet these limits using such technologies, you should consider whether advanced combustion control technologies such as rotating opposed fire air should be used to meet these limits.

Because of the relatively high NO_x emission rates of cyclone units, SCR is more cost-effective than the use of current combustion control technology for these units. The use of SCRs at cyclone units burning bituminous coal, sub-bituminous coal, and lignite should enable the units to cost-effectively meet NO_x rates of 0.10 lbs/mmbtu. As a result, we are establishing a presumptive NO_x limit of 0.10 lbs/mmbtu based on the use of SCR for coal-fired cyclone units greater than 200 MW located at 750 MW power plants.

As with the other presumptive limits established in this guideline, you may determine that an alternative level of control is appropriate based on your consideration of the relevant statutory factors. For other cyclone units, you should review the use of SCR and consider whether these post-combustion controls should be required as BART.

For oil-fired and gas-fired EGUs larger than 200MW, we believe that installation of current combustion control technology to control NO_x is generally highly cost-effective and should be considered in your determination of BART for these sources. Many such units can make significant reductions in NO_x emissions which are highly cost-effective through the application of current combustion control technology.²¹

²¹ See *Technical Support Document for BART NO_x Limits for Electric Generating Units* and

V. ENFORCEABLE LIMITS/COMPLIANCE DATE

To complete the BART process, you must establish enforceable emission limits that reflect the BART requirements and require compliance within a given period of time. In particular, you must establish an enforceable emission limit for each subject emission unit at the source and for each pollutant subject to review that is emitted from the source. In addition, you must require compliance with the BART emission limitations no later than 5 years after EPA approves your regional haze SIP. If technological or economic limitations in the application of a measurement methodology to a particular emission unit make a conventional emissions limit infeasible, you may instead prescribe a design, equipment, work practice, operation standard, or combination of these types of standards. You should consider allowing sources to “average” emissions across any set of BART-eligible emission units within a fence line, so long as the emission reductions from each pollutant being controlled for BART would be equal to those reductions that would be obtained by simply controlling each of the BART-eligible units that constitute BART-eligible source.

You should ensure that any BART requirements are written in a way that clearly specifies the individual emission unit(s) subject to BART regulation. Because the BART requirements themselves are “applicable” requirements of the CAA, they must be included as title V permit conditions according to the procedures established in 40 CFR part 70 or 40 CFR part 71.

Section 302(k) of the CAA requires emissions limits such as BART to be met on a continuous basis. Although this provision does not necessarily require the use of continuous emissions monitoring (CEMs), it is

important that sources employ techniques that ensure compliance on a continuous basis. Monitoring requirements generally applicable to sources, including those that are subject to BART, are governed by other regulations. See, e.g., 40 CFR part 64 (compliance assurance monitoring); 40 CFR 70.6(a)(3) (periodic monitoring); 40 CFR 70.6(c)(1) (sufficiency monitoring). Note also that while we do not believe that CEMs would necessarily be required for all BART sources, the vast majority of electric generating units potentially subject to BART already employ CEM technology for other programs, such as the acid rain program. In addition, emissions limits must be enforceable as a practical matter (contain appropriate averaging times, compliance verification procedures and recordkeeping requirements). In light of the above, the permit must:

- Be sufficient to show compliance or non-compliance (i.e., through monitoring times of operation, fuel input, or other indices of operating conditions and practices); and
- Specify a reasonable averaging time consistent with established reference methods, contain reference methods for determining compliance, and provide for adequate reporting and recordkeeping so that air quality agency personnel can determine the compliance status of the source; and
- For EGUS, specify an averaging time of a 30-day rolling average, and contain a definition of “boiler operating day” that is consistent with the definition in the proposed revisions to the NSPS for utility boilers in 40 CFR Part 60, subpart Da.²² You should consider a boiler operating day to be any 24-hour period between 12:00 midnight and the following midnight during which any fuel is combusted at any time at the steam generating unit. This would allow 30-day rolling average emission rates to be calculated consistently across sources.

[70 FR 39156, July 6, 2005]

Technical Support Document for BART NO_x Limits for Electric Generating Units Excel Spreadsheet, Memorandum to Docket OAR 2002-0076, April 15, 2005.

²² 70 FR 9705, February 28, 2005.